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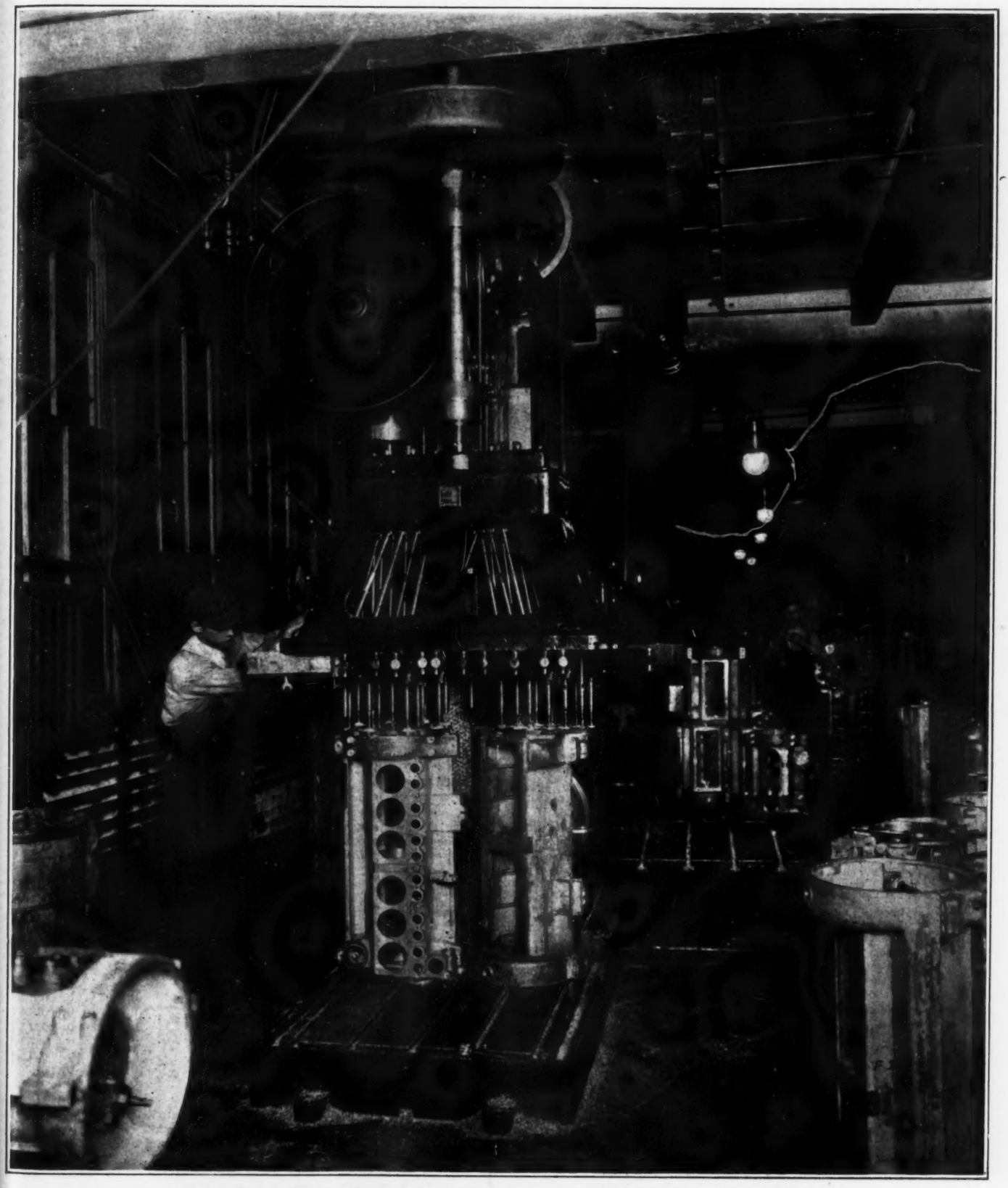


Fig. 1.—Thirty-spindle multiple drill boring holes in front and rear ends, respectively, of two crank-cases.

MACHINE TOOLS AND THE MOTOR CAR INDUSTRY.—[See page 260.]

Recent Discoveries in Physical Science—I*

Chemical Affinity Interpreted as an Electric Phenomenon

By Sir J. J. Thomson, O.M., F.R.S.

Of all the properties of atoms none exceed in interest and importance those concerned in the actions exerted between one atom and another. On these, in fact, depend not only such properties of matter as stiffness and tenacity, those involved in changes of state from solid to liquid, and from liquid to the gaseous conditions, the presence of crystals in some cases, and their absence in others; but in addition to these there is also involved the whole of the vast subject of chemistry. Both the physicist and the chemist, when they push their investigations far enough, find that they are striving toward the same goal. The problem of the physicist, however, relates rather to the action of atom on atom when free, while the chemist is concerned rather with the interaction of the atoms within the molecule. The foundation of both investigations is, however, the same.

For my own part, I am inclined to regret that one section of chemistry has been labeled "physical chemistry," and I should not be surprised if it proved that the greatest advances in atomic theory were made, not in this department, but in that part of chemistry which dealt with the structure of chemical compounds. The questions involved in the action of one molecule on another has been in debate for a very long time. Cauchy, Laplace, Boscovich have all made important investigations; but it will not, I think, be going too far to say that the results they obtained were not quite so definite as might have been wished. For my own part, I believe that greater definiteness would be secured by pursuing another line of research, which, so far as I know, has been originated by a very remarkable man, the late Mr. W. Sutherland. Mr. Sutherland contributed to the *Philosophical Magazine* nearly forty papers, but I am afraid that it must be admitted that these papers have not attracted the attention they deserve. In part this is due to the circumstance that Mr. Sutherland excelled as a philosopher rather than as an expositor. When, however, one gets at his meaning, his views appear to be, at bottom, of very great value.

Sutherland assigned to each atom a specific attracting power. He regarded an atom of hydrogen, for instance, as exerting a certain force on another atom. The law of this force (that was to say, its variation with the distance between the atoms) was, he held, the same for all atoms, but its magnitude depended on a specific constant, different for each element; hence there was one value for an atom of hydrogen, and a different value for an atom of oxygen, and so on. Sutherland sought to determine the value of these constants through certain hypotheses as to the nature of the forces exerted. He assumed that each atom contained both a positive and a negative charge, but that the negative charge was not in quite the same position as the positive one. There was thus a residual external field, each atom resembling a little magnet with its positive and its negative pole. Such a combination, would, like the magnet, exert a force, and constituted in fact what is known as an electric doublet. The moment of this doublet (that is to say, the product of either charge by the distance between the two charges) was in Sutherland's view, characteristic of any particular atom. Sutherland calculated out the value of these moments for various elements, basing his calculations on the principle that if atoms did exert force on each other, it would be necessary to do a certain amount of work to remove an atom from a mass of many others, and that this work would depend upon the magnitude of the forces involved. Sutherland succeeded in finding an expression for this work in terms of the moments of his electric doublets.

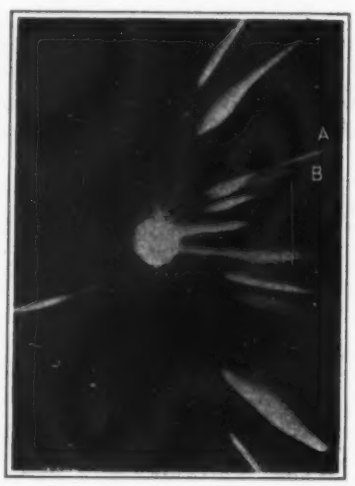
In the process of evaporation each atom or molecule evaporated is removed from the midst of very many other atoms or molecules. The molecules are, in short, torn away against the attractive forces exerted by those left in the liquid. The work spent in overcoming these attractive forces is measured by the latent heat, and Sutherland was accordingly able to express this latent heat in terms of the moments of the atoms of the liquid evaporated. In this way he calculated out the numerical values for these moments as tabulated below:

Element.	Moment of Electric Doublet.
H	0.75×10^{-18}
O	1.7×10^{-18}
N	1.8×10^{-18}
Cl	4.4×10^{-18}
Br	5.0×10^{-18}
I	6.2×10^{-18}

These values were obtained in part, as already indicated, by a comparison of Sutherland's theoretical expression with the actual value of the latent heat, but also through another line of investigation based on data as to the surface tension of liquids.

Having in this way obtained the value of the moments for hydrogen, oxygen, and carbon, it should be possible to calculate the latent heat for any compound of these elements, and obtain in this way a very efficient check on the validity of the theory proposed. On this check being applied, the amount of agreement between calculation and observation is sufficient to show promise; but the discrepancies make it evident that there is still some factor not taken into account, and which seriously affects the results.

The essence of Sutherland's theory is that the electric doublets are confined to the atom, each atom being accordingly neutral, containing as much positive as negative electricity, so that, on this view, we do not get in compounds one atom with a positive charge balanced by another atom with a negative charge. If, however, the atoms in a compound were individually charged, then the value of the latent heat would not depend on the atoms only, but on the arrangement of these atoms within the molecule, and the moment of the electric doublets would vary from compound to compound. Sutherland assumed, however, that compounds of this character did not exist, but that in every compound each atom was individually neutral.



Positive ray spectrum of carbon monoxide.
A. Carbon. *B.* Oxygen.

There is, however, some reason for believing that chemical compounds can be divided into two great classes, remarkably different in their properties. In the one class Sutherland's hypothesis holds true, and the atoms are not charged, while in the other type individual atoms in the molecule are oppositely charged. The distinction between the properties of the two classes is very remarkable. All chemically active compounds, such as H_2O, NH_3, HCl, and HCN, belong to the second class, and the atoms within their molecules carry charges. In these bodies, in short, we have a condition of intra-molecular ionization, one atom being positively electrified and another negatively charged.

I shall first try to show that there is the difference, above set forth, between various chemical compounds, and that in one class of these there are electric charges on the atoms of each molecule; for that very reason these molecules can produce strong chemical effects. This I shall show by proving that such a body can be electrified without adding electricity to it, or subjecting it to friction, but merely by straining it, the strain being brought about solely by a change of temperature. [Taking a crystal of tourmaline, Professor Thomson showed that if this crystal were dipped in liquid air, opposite ends of it became oppositely charged.]

The dipping of the crystal in liquid air causes it to contract, and this contraction is different in amount in different directions. There thus ensues a re-arrangement of the molecules inside the crystal. The atoms of the tourmaline are, no doubt, electrified even at the ordinary room temperature, though the crystal shows no evidence then of this, having got itself covered with a conducting film, which acts as a shield, and prevents any exhibition of an external field. When, however, the internal arrangement of the crystal is suddenly changed, the skin can no longer counterbalance the interior electrification, as it is a bad conductor, and a temporary electrification is obtained.

The experiment I have shown indicates the existence of bodies of which the constituents are charged up. The most direct proof of the existence of bodies, in which the constituent atoms are neutral electrically, is to be derived from the fact that when a gas is dissociated by a moderate rise of temperature, it does not become a conductor. Nickel carbonyl, for instance, dissociates readily at a very moderate temperature. If, when this splits up, one constituent is negatively, and the other positively, electrified, there should result a collection of positive and negative particles free to move, and if a potential difference were applied, a current should result. This experiment has been tried repeatedly at the Cavendish Laboratory, and no trace of conductivity has been found in the dissociating gas, so that the constituent atoms of this compound are certainly neutral, and there is here no intra-molecular ionization.

Nickel carbonyl is, however, a somewhat complicated compound, and it might be claimed that it does not provide the best chance for the separation of oppositely charged atoms. The molecule of carbon monoxide consists, on the other hand, of only two atoms, and since oxygen is intensely electro-negative, there would appear to be a good chance that on dissociation the carbon would be found with a positive charge, and the oxygen negatively electrified.

This can be tested as follows: When positive rays are obtained by means of a discharge tube, it is found that some of the molecules constituting these rays break up after having passed through the negative electrode and left the discharge tube. In the photograph, published herewith, there is evidence that this has occurred with some molecules of carbon monoxide. The carbon line in this figure is represented by *A*, and the oxygen line by *B*. The fact that molecules of CO are split up thus can be recognized by determining the energies the rays carry with them. So long as a molecule of CO is complete, both its constituent atoms are traveling at the same speed. The carbon atom has, however, a mass of 12, while that of the oxygen atom is 16. After the molecule is split up the original kinetic energy of the molecule is divided between the constituent atoms in these proportions, so that the carbon atom carries 12/28 of the original energy, and the oxygen 16/28. The carbon has thus less energy than the oxygen. The smaller the energy carried by a positive ray, the more it is displaced in the positive ray photograph. Looking at the carbon line *A*, it will be seen that this is bright near the origin, then fades away, and again becomes bright further on. This second bright portion is produced by carbon particles split off the carbon-monoxide molecule after the latter has passed out of the discharge tube. The oxygen line shows a corresponding variation in brightness, but the atom being heavier, this second bright bead is not so far from the origin as the corresponding carbon bead. On making accurate measurements, it is found that the relative displacement of these beads is exactly proportional to the relative masses, so that both come from a common molecule. Had the carbon been positively charged, and the oxygen negatively charged, the beading would be observable on the carbon line only, and the fact that it is found on both lines indicates that the constituent atoms of the carbon-monoxide molecule exist inside this molecule in the neutral state.

It will thus be seen, that in many compounds there is no charging up of the constituent atoms, while in others the atoms do carry charges.

In this connection the figures in the annexed table, showing for a number of compounds a comparison between $k-1$ and μ^2-1, are of much interest, k denoting the specific inductive capacity of the bodies listed, and μ the refractive index.

Gas.	$k-1$.	μ^2-1.
Air	0.00059	0.00059
H	0.00026	0.00028
CO^2	0.00094	0.00092
CO	0.00069	0.00067
H_2O	0.0070	0.00029
NH_3	0.0071	0.00075
HCl	0.0025	0.00089
$CH_3.OH$	0.006	0.0011

From this table it appears that the value of k and μ^2 is identical for air, and practically so for H, CO_2 and CO. When, however, we come to water vapor we have $k-1=0.0070$ and $\mu^2-1=0.00029$, so that the former is nearly twenty-five times the latter. In the case of ammonia the ratio, it will be seen, is about ten, for HCl it is rather less than three, and for methyl alcohol about six.

The enormous difference between the bodies listed

* First of a series of lectures delivered at the Royal Institution.

in the upper part of the table and those tabulated in the lower is due to the fact that in these latter compounds there is a charge on the constituent atoms. Moreover, not only have these gases an enormous specific inductive capacity, but this varies greatly with changes of temperature. Some figures observed with methyl alcohol are as follows:

Temperature Deg. Cent.	$k-1$.
93.2	264
103.1	237
120.5	218
139.1	204
148.6	198

The values given for $k-1$ are, in this case, of course, relative values, and not absolute values. With such gases as air, H, CO_2, and the like, the value of k is independent of the temperature; but it will be seen that with methyl alcohol, as the temperature changes from 93.2 deg. Cent. to 148.6 deg. Cent., the value of $k-1$ diminishes from 264 to 198.

This very rapid diminution of $k-1$ with temperature changes, is characteristic of bodies subject to intramolecular ionization, and I shall try to explain how it comes about that when the individual atoms are charged this temperature effect ensues. If a molecule of this kind were placed in a field of force, it would try to set itself in a definite direction—that in which its axis pointed along the line of force. The more it succeeded in maintaining this position, the bigger would be the specific inductive capacity.

Why does it arise, therefore, that all the molecules do not point in the required direction when under the action of electric force? It is because they knock against each other, and by their mutual collisions knock their axes out of line and prevent them pointing in the right direction. The more violent the collisions the more the axes are disturbed, and the less they will be set along the line of electric force, and the smaller in consequence the contribution made to the specific inductive capacity. Since the molecules knock each other about more at high temperatures, a rise of temperature will (with compounds having charged atoms) diminish the specific inductive capacity.

If, on the other hand, a conducting sphere were placed in a field of force, this force would, it is true, induce positive and negative charges at opposite poles of the sphere, but no knocking about of the sphere would shift the position of these charges. A collision might, in short, knock the sphere about, but it could not knock the electricity about. Hence, in the case of compounds with uncharged atoms, the specific inductive capacity is unaffected by a change of temperature.

The phenomena involved can be illustrated by means of a group of small magnets mounted on pivots. I have on the table a rectangular coil of wire traversed by a current, the magnetic field due to the current being balanced by a compensating coil traversed by the same current, so that the effect on a magnetometer is nil. On placing inside of the rectangular coil a tray of small mounted magnets, these set themselves along the line of force, and the balance being thus destroyed, the magnetometer shows a large deflection. On vigorously shaking the tray, however, thus throwing the magnets out of line, the deflection diminishes nearly to its original zero value, and on then leaving the tray at rest the large deflection is slowly regained as the little magnets gradually come to rest again. Replacing the magnets by corresponding pieces of soft iron, we see that the deflection of the magnetometer is unaffected by even the most vigorous shaking.

By the aid of the kinetic theory of gases, it is possible to calculate the effect of temperature in preventing the setting of molecules with their axes along the direction of an electric field. I have made this calculation for the gases tabulated in the lower half of the table already given. The expression I have obtained is:

$$k = a + \frac{0.88\ M^2 \times 10^{-36}}{T}$$

In this formula k is the specific inductive capacity, a a constant independent of the temperature, and equal to k, when k is itself equal to the square of the refractive index of the compound.

By M is denoted the moment of the doublet constituted by the charged atoms of the molecule, while T denotes the absolute temperature. This expression gives the value of k for a gas having the same number of molecules per cubic centimeter as corresponded to atmospheric pressure and 0 deg. Cent.

By making measurements of k the value of M can be determined. In the case of ammonia the result is that $M = 1.5 \times 10^{-18}$; for water, $M = 2.1 \times 10^{-18}$. It will be seen that, in view of the factor 10^{-18}, the moments are very small. On comparing them with the corresponding moment of the doublet in an atom of iodine, it appears, however, that the work required to separate two molecules of NH_3, if these were placed in the position in which their mutual attraction was strongest, is twice as great as that required to separate from each other the two atoms constituting a molecule of iodine.

If, however, as this calculation shows, the attraction which represents the residual affinity of two molecules of NH_3 is greater than that between the atoms of a molecule of iodine, how is it that at ordinary temperatures iodine is very little dissociated, while at these temperatures there are at the same time very few double molecules in a mass of NH_3? The reason is that if one takes two atoms of iodine, the charges being free to move inside the atoms, these atoms can attract each other, however the two are presented to each other; while the atoms in a molecule of NH_3 being themselves charged, two molecules of NH_3 will attract only if the right ends of the atoms are opposed, but there will be repulsion if the two molecules are shot against each other with an opposite orientation. It is, in short, only when the molecules strike each other in a few favored positions that they will stick together. I have also calculated the moments for various alcohols. For ethyl alcohol the value of k is very considerably less than for water, having the value 26 as compared with 81. The question arises how is this to be reconciled with the near equality in the values of M?

The explanation is that, in a given volume, one does not get nearly so many molecules of alcohol as of water. The weight of a molecule of alcohol is greater than that of a molecule of water, while at the same time the density is much less. Both these factors reduce the number of molecules contained in a cubic centimeter.

I have accordingly calculated out k on a different basis from that usual. On dividing k, as ordinarily determined, by the number of molecules in a unit volume, the quotient obtained represents the molecular specific inductive capacity. The figures thus obtained are tabulated in the last column of the annexed table, from which it will be seen that this molecular specific inductive capacity is much more constant than is k as ordinarily estimated:

Substance.	k.	$\frac{k}{N}$
Radical, — OH.		
Water	81.7	81.7
Methyl alcohol, $CH_3.OH$	32.1	79.0
Ethyl alcohol, $C_2H_5.OH$	21.7	84.0
Propyl alcohol, $C_3H_7.OH$	20.5	85.0
Glycerine, $C_3H_5(OH)_3$	56.2	79.0
Radical, — CN.		
Aceto-Nitrite, $CH_3.CN$	35.8	100.0
Propro-nitrite, $C_2H_5.CN$	27.2	102.0
Benoxyl-cyanide, $C_6H_5.OH_2CN$	16.7	109.0
Ethylene-cyanide, $(CH_2)_2(CN)_2$	57.3	127.0

(To be continued.)

Table of Feet Reduced to Decimals of a Mile

By James G. Wishart

THE table of feet reduced to decimals of a mile, shown herewith, will be found both accurate and convenient. The use of this table reduces the process to one of simple addition and in work where there is a quantity of this class of computing to be performed, will prove itself a time saver. The table has been figured to the fifth decimal, reducing to a minimum any errors due to the addition of several of the quantities.

TABLE OF FEET REDUCED TO DECIMALS OF A MILE.

Feet.	0	10	20	30	40	50	60	70	80	90
0	.00000	.00189	.00379	.00568	.00758	.00947	.01136	.01326	.01515	.01705
1	.00019	.00208	.00398	.00587	.00777	.00966	.01155	.01345	.01534	.01723
2	.00038	.00227	.00417	.00606	.00795	.00985	.01174	.01364	.01553	.01742
3	.00057	.00246	.00436	.00625	.00814	.01004	.01193	.01383	.01572	.01761
4	.00076	.00265	.00455	.00644	.00833	.01023	.01212	.01402	.01591	.01780
5	.00095	.00284	.00473	.00663	.00852	.01042	.01231	.01420	.01610	.01799
6	.00114	.00303	.00492	.00682	.00871	.01061	.01250	.01439	.01629	.01818
7	.00133	.00322	.00511	.00701	.00890	.01080	.01269	.01458	.01648	.01837
8	.00152	.00341	.00530	.00720	.00909	.01098	.01288	.01477	.01667	.01856
9	.00170	.00360	.00549	.00739	.00928	.01117	.01307	.01496	.01686	.01875
100	.01894	.02083	.02273	.02462	.02652	.02841	.03030	.03220	.03410	.03598
200	.03788	.03977	.04167	.04356	.04545	.04735	.04924	.05114	.05303	.05492
300	.05682	.05871	.06061	.06250	.06439	.06629	.06818	.07008	.07197	.07386
400	.07576	.07765	.07955	.08144	.08333	.08523	.08712	.08902	.09091	.09280
500	.09470	.09659	.09848	.10038	.10227	.10417	.10606	.10795	.10985	.11174
600	.11364	.11553	.11742	.11932	.12121	.12311	.12500	.12689	.12879	.13068
700	.13258	.13447	.13636	.13826	.14015	.14205	.14394	.14583	.14773	.14962
800	.15152	.15341	.15530	.15720	.15909	.16098	.16288	.16477	.16667	.16856
900	.17045	.17235	.17424	.17614	.17803	.17992	.18182	.18371	.18561	.18750
1,000	.18939	.19129	.19318	.19508	.19697	.19886	.20076	.20265	.20455	.20644
100	.20833	.21023	.21212	.21402	.21591	.21780	.21970	.22159	.22348	.22538
200	.22727	.22917	.23106	.23295	.23485	.23674	.23864	.24053	.24242	.24432
300	.24621	.24811	.25000	.25189	.25379	.25568	.25758	.25947	.26136	.26326
400	.26515	.26705	.26894	.27083	.27273	.27462	.27652	.27841	.28030	.28220
500	.28409	.28598	.28788	.28977	.29167	.29356	.29545	.29735	.29924	.30114
600	.30303	.30492	.30682	.30871	.31061	.31250	.31439	.31629	.31818	.32008
700	.32197	.32386	.32576	.32765	.32955	.33144	.33333	.33523	.33712	.33902
800	.34091	.34280	.34470	.34658	.34848	.35038	.35227	.35417	.35606	.35795
900	.35985	.36174	.36364	.36553	.36742	.36932	.37121	.37311	.37500	.37689
2,000	.37879	.38068	.38258	.38447	.38636	.38826	.39015	.39205	.39394	.39583
100	.39773	.39962	.40152	.40341	.40530	.40720	.40909	.41098	.41288	.41477
200	.41667	.41856	.42045	.42235	.42424	.42614	.42803	.42992	.43182	.43371
300	.43561	.43750	.43939	.44129	.44318	.44508	.44697	.44886	.45076	.45265
400	.45455	.45644	.45833	.46023	.46212	.46402	.46591	.46780	.46970	.47159
500	.47348	.47538	.47727	.47917	.48106	.48295	.48485	.48674	.48864	.49053
600	.49242	.49432	.49621	.49811	.50000	.50189	.50379	.50568	.50758	.50947
700	.51136	.51326	.51515	.51704	.51894	.52083	.52273	.52462	.52652	.52841
800	.53030	.53220	.53409	.53598	.53788	.53977	.54167	.54356	.54545	.54735
900	.54924	.55114	.55303	.55492	.55682	.55871	.56061	.56250	.56439	.56629
3,000	.56818	.57008	.57197	.57386	.57576	.57765	.57954	.58144	.58333	.58523
100	.58712	.58902	.59091	.59280	.59470	.59659	.59848	.60038	.60227	.60417
200	.60606	.60795	.60985	.61174	.61364	.61553	.61742	.61932	.62121	.62311
300	.62500	.62689	.62879	.63068	.63258	.63447	.63636	.63826	.64015	.64204
400	.64394	.64583	.64773	.64962	.65152	.65341	.65530	.65720	.65909	.66098
500	.66288	.66477	.66667	.66856	.67045	.67235	.67424	.67614	.67803	.67992
600	.68182	.68371	.68561	.68750	.68939	.69129	.69318	.69508	.69697	.69886
700	.70076	.70265	.70454	.70833	.70833	.71023	.71212	.71402	.71591	.71780
800	.71970	.72159	.72348	.72538	.72727	.72917	.73106	.73295	.73485	.73674
900	.73864	.74053	.74242	.74432	.74621	.74811	.75000	.75189	.75379	.75568
4,000	.75758	.75947	.76136	.76326	.76515	.76704	.76894	.77083	.77273	.77462
100	.77652	.77841	.78030	.78220	.78409	.78598	.78788	.78977	.79167	.79356
200	.79545	.79735	.79924	.80114	.80303	.80492	.80682	.80871	.81061	.81250
300	.81439	.81629	.81818	.82008	.82197	.82386	.82576	.82765	.82954	.83144
400	.83333	.83523	.83712	.83902	.84091	.84280	.84470	.84659	.84848	.85038
500	.85227	.85417	.85606	.85795	.85985	.86174	.86364	.86553	.86742	.86932
600	.87121	.87311	.87500	.87689	.87879	.88068	.88258	.88447	.88636	.88826
700	.89015	.89204	.89394	.89583	.89773	.89962	.90152	.90341	.90530	.90720
800	.90909	.91098	.91288	.91477	.91667	.91856	.92045	.92235	.92424	.92614
900	.92803	.92992	.93182	.93371	.93561	.93750	.93939	.94129	.94318	.94508
5,000	.94697	.94886	.95076	.95265	.95454	.95644	.95833	.96023	.96212	.96402
100	.96591	.96780	.96970	.97159	.97348	.97538	.97727	.97917	.98106	.98295
200	.98485	.98674	.98864	.99053	.99242	.99432	.99621	.99811	1.0000	1.0019
	0	100	200	300	400	500	600	700	800	900
6,000	1.13636	1.1553	1.1742	1.1932	1.2121	1.2311	1.2500	1.2689	1.2879	1.3068
7,000	1.32576	1.3447	1.3636	1.3826	1.4015	1.4205	1.4394	1.4583	1.4773	1.4962
8,000	1.51515	1.5341	1.5530	1.5720	1.5909	1.6098	1.6288	1.6477	1.6667	1.6856
9,000	1.70455	1.7235	1.7424	1.7614	1.7803	1.7992	1.8182	1.8371	1.8561	1.8750
10,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	90,000	100,000	500,000
1.8939	3.7879	5.6818	7.5758	9.4697	11.364	13.258	15.152	17.045	18.939	94.697

The figures across the top of the table are even feet in tens. The figures in the first vertical column are even feet, hundreds and thousands. The figures shown across the bottom of the table are the miles in decimals for the even ten thousands of feet shown immediately above. To ascertain the miles that any number of feet represents, proceed as follows: Given 8,673 feet to find the number of miles. First look in the vertical column headed 70, opposite the figure 3 in the first column and you will find 0.01383 mile, which is 73 feet reduced to miles. Similarly in the column headed 0, opposite the figure 600 in the first column you will find 0.11364 mile, which is 600 feet reduced to miles, and in the column headed 0, opposite the figure 8,000 in the first column you will find 1.51515, which is 8,000 feet reduced to miles. The sum of these three numbers equals 1.64262 miles.—*Railway Age Gazette.*

The Hat-pin Menace.

EVERYONE knows that a hat-pin point, protruding several inches beyond the brim of a woman's hat, is a source of danger to anyone in close proximity to the wearer of the pin. Probably no one sees the more serious consequences so frequently as the eye specialist. Sometimes the injury consists of a mere scratch, which heals readily and leaves no permanent defect. On the other hand, every now and then the scratch becomes infected and serious impairment of sight, if not actual loss of the eye, results. One who has seen these bad results is forever alarmed for himself and others when he sees a protruding hat-pin point in a crowded car or theater lobby or wherever people are closely crowded together. It ought not to be necessary to pass laws to prevent such accidents, but as the number of such cases does not decrease it would seem to be desirable to make the wearing of shorter hat-pins obligatory. There are devices on the market for covering and protecting the end of a hat-pin which are effective and inexpensive. Any jeweler can shorten a long hat-pin in a few minutes and at a cost of a few cents, thereby, perhaps, save a fellow being's eye.—*Journal American Medical Association.*

Fig. 2.—The "automatic" department of a busy automobile factory.

Machine Tools and the Motor Car Industry

Several Interesting Machines Used in the Manufacture of Automobiles

THERE is no other industry that has done more for the development of machine tools than the manufacture of motor cars. The early days of the automobile were not marked by a struggle for existence. It developed by leaps and bounds and attained a phenomenal growth overnight. No expense was spared. Old models were scrapped and new designs turned out every year. Naturally all this was attended by a boom in the manufacture of machine tools, which were ordered in increasing quantities and had to be remodeled constantly to meet the changes in the motor car. Now the automobile has passed the stage of experiment; parts are becoming standardized; methods of manufacture are being reduced to a system; nevertheless the demands upon the machine-tool manufacturer continue, for now the crying needs are for greater output and more economical production, owing to keener competition. Pressed for time and for space, the motor car manufacturer is calling for machines that will perform a score of operations simultaneously, or that will handle a number of castings at one setting.

Several interesting machine tools used in motor car manufacture are pictured herewith. Our front page illustration this week shows an unusually large multiple drill as used in a prominent automobile factory. It is provided with thirty spindles, the majority of which are shown in use. One set of drills is boring holes in the forward end of a crank case, while at the same time another set is drilling the holes in the rear end of another crank case. When this operation is completed the castings are turned end for end and substituted one for the other, when the spindle head is fed down a second time to complete the work upon the crank cases. It takes some time to adjust the spindles to the proper position and also some time to prepare the jigs which will insure perfect centering of the drills upon the work. But once this is done absolute uniformity in all castings is assured and the time saved over the old method of drilling each hole, separately, can well be imagined.

A novel machine, developed recently by the automobile industry, is shown in Fig. 3. It is an automatic drill, capable of performing two separate operations. The picture shows it boring radial holes in a flange. Once the work is set the holes are spaced and drilled automatically. By means of change gears, any number of divisions within the ordinary range may be secured. By turning the table down to horizontal position the machine may be used to drill screw-driver holes in valves which are held in a jig. The spindle is double,

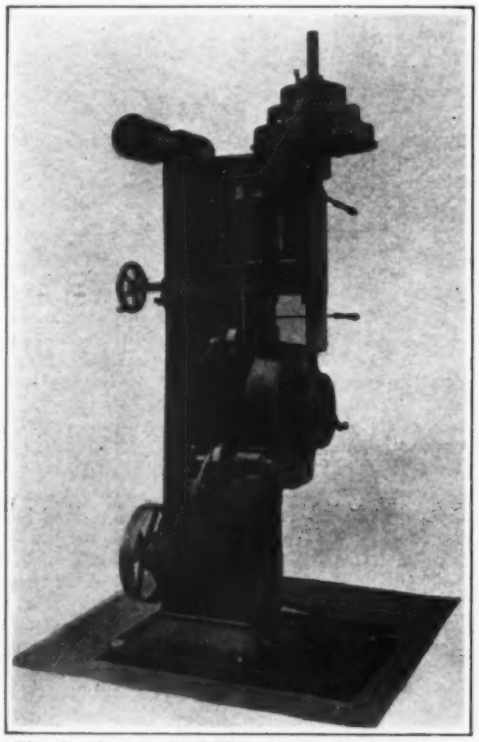


Fig. 3.—Automatic drill boring radial holes in a flange.

so that when the table is turned down to horizontal position to receive the valves, they may be drilled two at a time. After being drilled they are automatically ejected by a cam beneath the table. As many as forty-four valves per minute have been drilled on this machine.

It is in the automatic machine that we find the greatest and most interesting development; for here we see tools operating simultaneously or consecutively without any operator to drive them, and cutting out screws, bolts, collars, and various small parts used in large numbers in an automobile. However, the work is not confined to small pieces. Fig. 4 shows some of the larger pieces that are turned out by an automatic machine. In the foreground is a shaft, which it will be observed has nine different diameters and eight shoulders; all of these diameters and shoulders having to be finished within 0.002 inch. All that is necessary, when this piece drops from the automatic machine is to center one end and grind it to size. The work is done in two operations as indicated in Fig. 5, and the time for nickel steel is 9½ minutes, while for machine steel it is 6½ minutes. Six or eight years ago it would have taken twenty-five minutes to have turned this shaft all over.

Back of the shaft, in Fig. 4, and to the right, is a small piece made for a demountable rim, which is turned out by an automatic machine in 60 seconds. The longest operation consists of turning the ends and cutting the piece off. The worm is produced in only a few seconds. When the part is fed forward and the forming takes place, the end is steadied before the thread is cut; then the hob is sunk, revolving at the right time; as it is tied to the spindle head of the machine, belt slippage has no effect, should it take place. The hob drops down into the work, like the head of a milling machine, and when it reaches its depth the slide carrying this mechanism is moved along for three sixteenths of an inch, which means that the bottom of the thread has a parallel surface three sixteenths of an inch wide. The other two pieces in the illustration are a large sleeve cut from a solid bar and finished inside and out, and a shell which is recessed inside. The machine which performs this work will make a recess of any depth required.

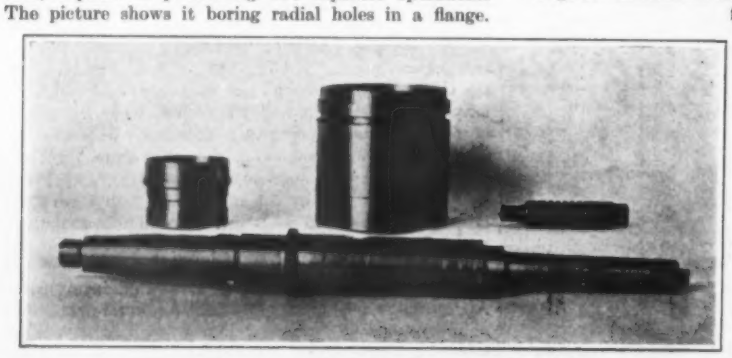


Fig. 4.—Work of an automatic machine.

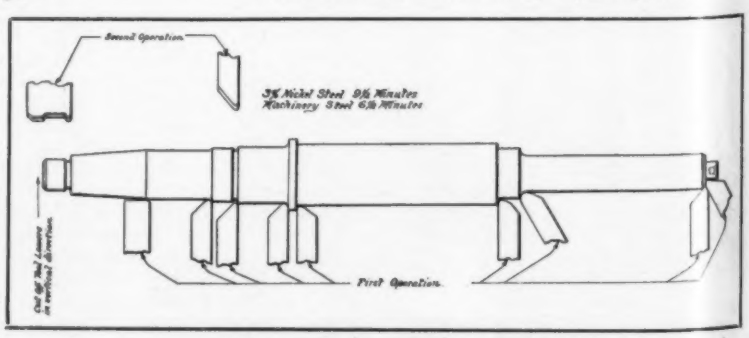


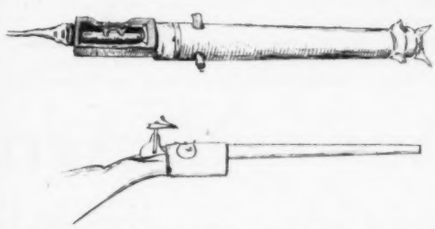
Fig. 5.—How the tools come into play.

Fig. 1.—Old engraving showing artillery of the fifteenth century. From a MS. in the University Library, Goettingen.

Evolution of the Breech-Loader

The Origin of Fire Arms Dates Back to Remote Antiquity

By Alex. Del Mar, Mining Engineer



Figs. 2 and 3.—A breech-loader of 1516 and a flint-lock revolver of the seventeenth century. Dresden collection.

NATIONAL prejudice has buried the history of artillery and its propulsory (gunpowder) under such a mass of fable that it involves some hardihood to set forth what appears to be the truth of the matter.

Niter, nitrate of potash, or saltpeter is a natural product of China, India and Persia. Until very recently India was the principal source of its supply to Europe; the crude product being the result of lixiviating the soil of alkaline deserts and allowing the solution to crystallize. Mixed with sulphur and charcoal it is converted into gunpowder, and as such was used for making fireworks (rockets, etc.) in China and India "many centuries" says Chambers, "before the Christian era." The fire rocket being a miniature breech-loading cannon, it is inconceivable that any people knowing how to make and discharge a rocket should have refrained from its use as a means of warfare. The Chinese annals published by the 16th century Jesuits, relate that rockets were used for this purpose in Vouti's conquest of Bengal, 90 B. C. Indeed, there is an interdict against the use of explosive compounds in the ancient Vedas.

Before the invention of felted paper the rocket was made of bamboo, with a few hoops to resist the explosive force of the powder within.

Paper was invented in the reign of Vouti's predecessor. "Before the reign of Ven-ti (179–156 B. C.) everything was written on bamboo slats with an iron stylus. In Ven-ti's reign paper was made by grinding bamboo in mills made for the purpose. Flowing ink and pencils made of hair were also invented." Thereafter rockets were made of paper or pasteboard.

Bamboo rockets were introduced from the Orient by the Greeks before our era under the name of Greek Fire; they were used in the Roman circus at the time of Augustus; again under Claudius, Carinus, Diocletian and other emperors; while gunpowder is plainly indicated in a muddled passage of Pliny, where its three ingredients occur in one sentence: "*Nitrum*, nec non frequenter liquatum cum *sulphure*, coquentes in *carbonibus*." (Manilius, Astron. v, 428–443; Pliny, xxi, 46 (10); Vopiscus, in vita Car.)

After this evidence it seems absurd to quote Friar Bacon, Father Schwartz or the other medieval claimants who fill the labored pages of Beckmann's "History of Inventions."

Between the reign of Diocletian and the Independence of Florence, fireworks were made a State secret and monopoly of the Greek empire, and the only allusions to gunpowder or fireworks or firearms occur in a treaty of 568, in the essay of Marcus Græcus, about 775, and the works of Arabian chemists. Marcus directs the explosive to be made of 1 pound of sulphur, 2 of charcoal and 6 of saltpeter: "'If this powder be tightly rammed into a long narrow tube closed at one end and then fired, the tube will fly through the air'; this is clearly the rocket. . . . The Arabs made their automatic fire from equal parts of sulphur, saltpeter, sulphide of antimony and the juice (carbon?) of the black sycamore." (Draper.)

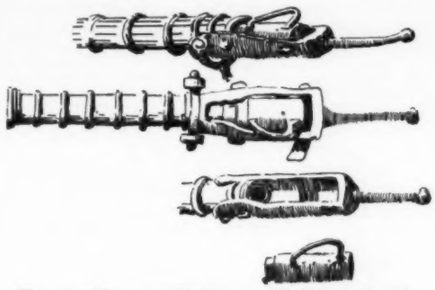


Fig. 4.—Vienna collection, quick-firing, breech-loading cannon, about 1500.

Shows the chamber and its use. Lowest figure, the chamber containing the powder charge. Next above, shows the cradle to hold the chamber. Next, part of the chase removed. Shows chamber wedged in, with ball in front. Top, ready for firing; fork, and trunnions for vertical and horizontal movement.

In the defeat which Louis XI sustained above Damietta (1249), the Ayyubite sultan is believed to have used artillery, but it is only in February, 1326, when the republic of Florence gave authority to its Council of Twelve to superintend the manufacture of brass cannon (crakys of war) and iron balls for the defense of the commonwealth, that a definite era for modern firearms was established.

Four years after this cannon were made at Windsor Castle; in 1339 a breech-loader with two barrels was set up in the Guildhall of London; and in 1345 artillery won the battle of Crecy.

Between the 14th and 15th centuries the princes of Europe made the production of saltpeter a *regale* and thus barred all progress in the improvement of firearms. In 1419 the Bishop of Magdeburg made saltpeter a "regale" of his See; in 1479 Bishop Ernest of Prussia made saltpeter a "regale" of his See, which lasted until the French Revolution; facts which suggest that it had been previously made a "regale" by the princes of the Greek empire.

In the face of these circumstances, the collections of 15th, 16th and 17th century breach-loaders and revolving pistols, to be seen to-day in the museums of Vienna and Dresden, which at first are so surprising to the visitor, lose something of their novelty. So far are they from being the prototypes of modern firearms—they are the result of more than twenty centuries of previous inventions.

Nevertheless, the collections are full of historical interest. Fig. 4 shows a replica of the breech-loaders with which Cortes conquered Mexico in 1521 and thus established a Roman empire in the New World. These are the breech-loaders and fire rockets with which, in 1683, John Sobieski drove Mahomet IV and his 300,000 Turks from those walls of Vienna which had been built with the ransom of Richard Cœur de Lion.

One cannot help fancying that pagan Rome arose from its grave to save Europe from Moslem supremacy. Roman art is everywhere in evidence. The matchlocks are a product of the Roman cross-bow; the bayonets were invented in Roman Bayonne; the revolving pistols in Tuscan Pistoia; even the fashion of them was of ancient Rome. There were several types of revolvers, one of them of the Roman mouse-trap design, its six chambers turning in the plane of the barrel; and all of them with locks of old Roman patterns.

At Warwick Castle Col. Colt's first revolving pistol is deposited, together with a letter in his own hand acknowledging his indebtedness to the inventor

Fig. 5.—Representation of a cannon. c. 1390 to 1400. From a MS. in the Royal Library, Munich.

Fig. 6.—Barrel of Thibetan war rocket.

Fig. 7.—Another engraving of the same date and source as Fig. 5.

of an earlier (British) revolver. One cannot help reflecting that unless Col. Colt was ignorant that the British revolver had been borrowed from Tuscany, he never would have penned so generous an admission.

Even big cannon are not modern. The Arabian conquerors of India constructed a siege piece weighing no less than 64,000 pounds, which is still to be seen at Dacca. At the siege of Ardres, 1375, the French used cannon carrying balls of 200 pounds weight. At Odruik, 1377, no fewer than 140 cannon were employed, some of them carrying balls of 250 pounds. At Chioggia, 1380, the Venetians used a bombard which breached the campanile of Brondolo and killed 22 men, including the Genoese commander, Pietro Doria—the work of a single shot. At the siege of Oudenarde, 1382, the Flemings used a bombard with a bore of 26 inches and a length of 19 feet; while to cap this climax of monstrosities the Duke of Burgundy of the same period constructed a siege piece which threw a stone ball weighing no less than 450 pounds. (Brackenbury in *Proc. Royal Artillery Inst.*)

The Decline of the American Navy

How the United States are Falling Behind Other Powers

By Sidney Graves Koon, M.M.E.

THE impetus with which the American Navy emerged from the Spanish War was entirely spent eight years later. Appropriations for new ships were grudgingly furnished by Congress, and barely covered wastage by age. Four years in the last eight have seen only a single battleship authorized—the other four saw two each—a total of twelve. Meantime, Germany has built twenty-six and England forty-two.

We are not at war—we may never again have a war in which naval force would count heavily. But—it might come to-morrow. Monroe Doctrines—Asiatic exclusion—Canal policies—Philippine control—supremacy in the Pacific—cannot be upheld by pedantic

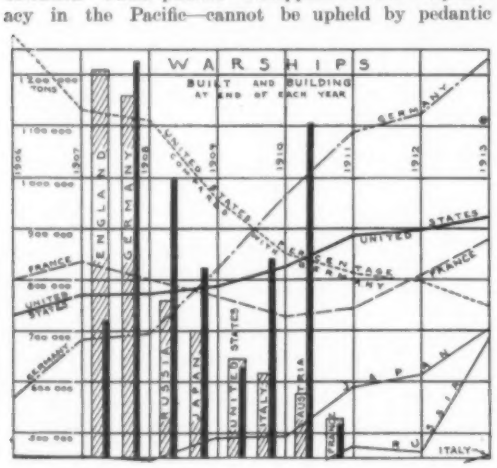


Fig. 1.

platitudes. The possession of an admittedly adequate fleet in 1898 would have avoided entirely the war with Spain. Lack of proper power may yet precipitate another conflict in which we might not be so fortunate—a conflict with an opponent fully able to take advantage of our weakness.

Except between nations with contiguous land frontiers, control of the sea is essential to the successful prosecution of war. Whether this comes after complete test of strength, or is evident from the beginning, success cannot be had without it. Modern navies cannot be improvised—they cannot be built overnight. Four monitors, authorized by Congress in the fond hope that they could assist in wresting victory from Spain, were completed nearly five years after that brief struggle had passed into history.

What are the causes which have permitted our fleet to lag so lamentably? Principally party politics—partly lack of information on the part of those who should know the truth—those whose duty it is, under the Constitution, to "provide for the common defence." "But," it will be urged, "we are not attacked." No more were we in 1898, until the memorable night of February 15th. No more was Russia in 1904, until the "Variag" was sunk and the fleet at Port Arthur torpedoed where it lay at anchor. Wars are *finished*, now, in less time than it took to *start* them, sixty years ago.

Just how fast are we falling behind?

Last year we did not launch a single armored ship. England launched five; Germany, six; France, three; Japan, three; Russia, two; Italy, two; Brazil, Spain, Turkey, and Chile, one each. We laid down only one ship to five for England; three for Germany; four for France; three for Japan; two for Italy. In the past three years we have completed five ships, totalling 122,650 tons; England, sixteen ships, of 358,050 tons; Germany, thirteen ships, of 300,236 tons; France, seven ships, of 136,334 tons.

But the diagrams, all based on reports of the Bureau of Intelligence, United States Navy Department, tell the story more clearly than words. The first two show the situation at the end of each year, from 1906 to 1913. Our position seven years ago, contrasted with that at the end of 1913, shows how mightily we have fallen. In not a single year of those seven has Germany failed to register a gain—80,000 tons last year, or nearly a tenth of our entire navy. From 1908 to 1911 Germany advanced 394,000 tons; we only 115,000 tons. Even decadent France, 144,000 tons behind us in 1911, has made up all but 46,000 tons—a clear gain of 98,000 tons in two years. Japan has gained 110,000 tons on us since 1910; Russia more than 200,000 tons in one year.

At the present rate of progress, how long can our navy be regarded as first class? Is it that now?

The cross-hatched areas in Fig. 1 indicate the tonnage by which the eight principal navies have increased since 1906. We trail along behind Russia and Japan, with less than a third of the increases shown by Germany or England. France alone, of all the eight powers, has a smaller percentage gain (indicated by the solid black vertical line).

The dotted line, crossing the diagram from "Northwest" to "Southeast," gives a history of the percentage which the strength of the United States navy has borne to that of Germany during the period under review. Starting with 128.7 per cent at the end of 1906, we were first passed by our Teutonic rival in 1909. Our ratio now is 75.1 per cent. This loss of 53.6 per cent may well cause worry to those who look to see our world policies maintained with undiminished vigor, and with that respect to which they are entitled.

The present comparative strengths of these two navies are differently indicated by computations made by the Naval General Board, in which the total muzzle energy of the broadside of all the American battleships is given as 8,507,548 foot tons; of the German battleships, 11,209,657 foot tons, or 32 per cent greater. This compares very closely with the 33 per cent excess in German tonnage, indicated above.

[The historical sketch as regards Russia is incomplete, the earlier tonnages being far below the lower limit of the chart. Italy appears only in 1913 and Austria not at all, for the same reason. England, starting with 1,851,854 tons in 1906 and running up to 2,611,291 tons in 1913, is away off the top of the chart.]

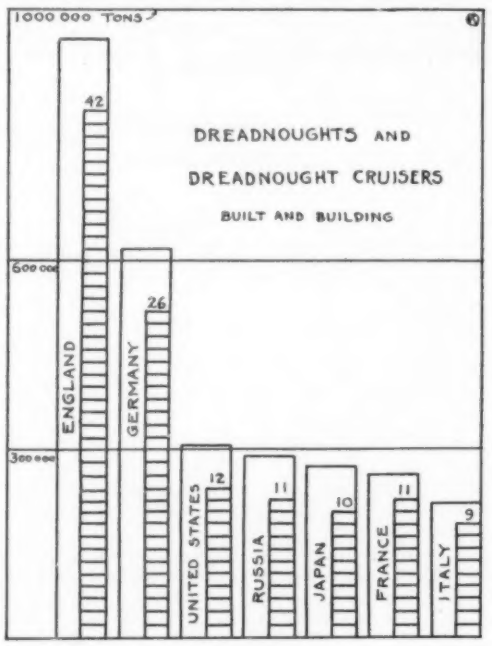


Fig. 3.

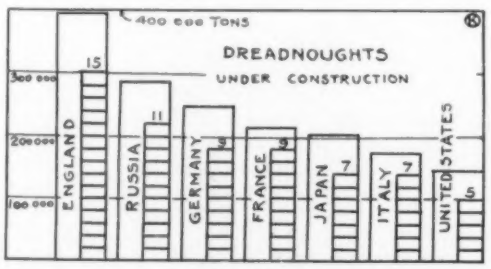


Fig. 4.

In Fig. 2 are shown only the "First line" ships ready for duty. Under this heading are included all dreadnoughts and battle cruisers (with eight or more heavy guns); also all battleships on which are carried (in addition to four 12-inch guns) at least eight 8-inch or four 9.2-inch guns, or heavier. No ship unable to steam 18 knots is included here, nor is any uncompleted ship. The closeness of our force to England's, in 1906, 1907, and 1908, is notable. In 1907 each had ten ships,

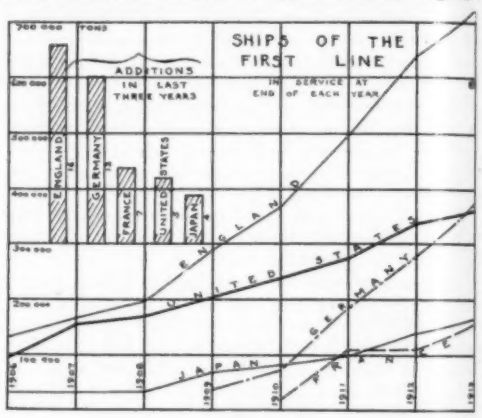


Fig. 2.

ours being a trifle smaller. Now we have about *half* England's force in ships of this type.

This diagram markedly favors the United States, particularly as regards Germany, for none of the German pre-dreadnought ships could qualify here, while thirteen of our twenty are of that type. We have only seven dreadnoughts represented in the chart, while Germany has seventeen and England twenty-seven. As many naval writers now wear spectacles opaque to pre-dreadnoughts, the inference is obvious—we are dropping out of the race so fast that it makes us wonder where we are going to land. The additions to this type of ship during the past three years are shown in the upper left corner, where the cross-hatched area represents displacements, while the figures indicate the number of ships.

Considering, as many now do, only ships of the dreadnought type, Fig. 3 gives the situation at the end of 1913. We are a very poor third in ships built and building, and are followed so closely by Russia, Japan, France, and even Italy, that a single ship or two would bridge the difference. We have less than half the power possessed by Germany, and less than one third that of our British cousins. *May we never have real need of a naval force until we are better equipped with it!*

But there's the whole trouble—we're *not getting better equipped*. Fig. 4 shows us absolutely last, both in number and displacement of ships now building. And unless some powerful friend of the navy, and of the nation, takes some highly effective action right soon, last is where we'll stay. The editor of the SCIENTIFIC AMERICAN was quite right when he stated, in the issue of March 7th, page 203:

"The work of bringing the American Navy up to the standard of strength called for by our national policies is by far the most pressing question now before the American people, its Congress and its President."

An Exhibition of Insects.—Organized by Prince d'Arenberg, an exposition of insects of all kinds, both useful and harmful, and also of insectivorous birds, will be held at Paris during the month of June next, under the patronage of the Department of Agriculture. The idea in the present event is to organize an effective means of defense against destructive insects, and the profits of the exposition will go toward developing or founding entomological stations and laboratories throughout the country.

Desirable Developments in Ship Dimensions *

As each successive large steamship is launched, curiosity is naturally aroused as to what is the next probable development, particularly in respect of size. From the description of the White Star liner "Britannic," which we published recently, it will be seen that in point of size she does not greatly exceed her last precursor of the same steam-ship line, the "Olympic"; but it must not be assumed from this that there is anything final in the proportions adopted. On the other hand, we have clear evidence that it is only the restrictions imposed by the depth of water in harbors and channels which preclude a very material change in the dimensions of ships. The Dominions Royal Commission, which have been devoting a considerable amount of attention to oversea communications, as well as to other problems associated with the Empire, were fortunate in securing a memorandum by Lord Pirrie, with special reference to the influence of depth of harbors on the dimensions of ships and on the cost of ocean transport. Lord Pirrie expressed the preference for at least 45 feet as the minimum depth which harbor engineers should recommend and work for, because although at the present moment 40 feet might be a satisfactory minimum working depth, the demands from shipping using the ports would grow so steadily as to make 45 feet necessary before even this depth could be achieved. The limitations hitherto imposed by depth of channels had involved, his lordship pointed out, a more rapid increase in the length and breadth of modern ships than in the draught; and yet that increase in draught would yield more important advantages than the augmentation of other dimensions. He found support for this belief in the success which had resulted from the larger vessels built by his firm for the Australian trade as a consequence of the increased draught now becoming available at Melbourne.

As to the actual effect of increased draught on the economy of ships, Prof. Sir John H. Biles gave to the Dominions Commission some suggestive data. It may be remembered that some years ago he tackled the problem and presented to the Institution of Naval Architects a lucid case in favor of increased depth. His paper on that occasion took as a basis a 500-foot cargo-carrier of 28 foot draught and 12 knots speed. By increasing the length of the ship to 700 feet without increasing the draught the actual cost of cargo-carrying would be increased from $2 to $2.25 per ton on a 5,000 sea-mile voyage, whereas were the draught increased in correct ratio to the length of the ship the cost would be reduced from $2 in the 500-foot ship to $1.75 per ton in the case of the 700-foot steamer. In other words, advance in size, including depth of hull, if rendered possible by deeper channels and harbors, would convert the loss of 60c. in the 700-foot ship to a gain of 30c., as compared with the 500-foot ship on a 5,000-mile voyage. Sir John Biles made further interesting investigations specially for the Dominions Royal Commission, the type ship in this case being a passenger and cargo steamer of 490 feet and of 14 knots speed. The length of voyage assumed was 3,000 sea-miles, and a comparison was made between two conditions, one involving a constant draught of 28 feet 3 inches—although the length might range up to 1,000 feet—and the other a draught varying as the length. It was found that in a 700-foot ship the cost of transport per ton in a ship in which draught was limited (28 feet 3 inches) was one and a half times as great as that in a ship of the same length but of proportionate draught. In a 900-foot ship the cost was twice as great, and in a 1,000-foot ship it was two and a half times as great. This is accountable from first principles. Sir John pointed out that the weight of hull for the restricted-draught vessel increased much more rapidly than the displacement. The beam could not be increased in the same ratio as the length, or the stability conditions would be interfered with. Before a great length was reached, the dead weight carried no longer increased as the length of the vessel increased, but began to decrease relatively. Further, the excessive proportion of breadth to draught in the large vessel of restricted draught was bad from the point of view of resistance, and therefore those running costs which depended on the power of the machinery were considerably increased. In this line of reasoning there is full justification for future "Britannics," especially if, as Lord Pirrie rightly points out, harbors are developed to suit the real economic needs.

Lord Pirrie pleaded for an increase in depth of harbors to at least 45 feet, but in Prof. Biles's 1,000-foot ship the actual draught works out at 57 feet 6 inches if the most desirable draught is to be adopted. If the draught cannot be varied as the linear dimensions, the fullest economy cannot be realized. For instance, assuming that a harbor had a working draught of 40 feet, as suggested by Lord Pirrie as immediately necessary, the dimensions corresponding to this draught for a 14-knot ship would be about 700 feet by 87 feet by 71 feet 4 inches depth. Were the dimensions increased without augmentation of draught, the cost of carrying cargo would be rapidly increased, and thus it becomes interesting to investigate the most economical length for ships of a given speed. In the case of a 12-knot purely cargo ship there would, according to Sir John Biles, be no appreciable variation between 700 feet and 800 feet. In a 14-knot vessel the economical length would be 700 feet if there were no revenue from passengers; but if the vessel were full of passengers, a 1,000-foot ship would be as economical as a 750-foot vessel if possible reductions could be made in the weight of hull of the former due to improvements in construction. At 17 knots the economic length for cargo-carrying without passengers would be 800 feet, and with passengers a 1,000-foot ship would give about the same economy as an 800-foot ship. For a 20-knot speed the most economical length would be about 950 feet for cargo revenue only, so that a 1,000-foot ship, when carrying passengers, would certainly not, in Sir John's view, be above the economical length. A 1,000-foot ship required a draught of 57 feet 6 inches if the correct proportions be adopted. No doubt some reduction in this draught would result from a reduction in the weight of structure, but Sir John seemed to think that it was not unreasonable to predict that within twenty or thirty years a depth of harbor of 60 feet could be profitably employed.

This view is the more justified in consequence of the steady increase in the number of large ships being built and in process of construction. The Dominions Royal Commission also desired to get information regarding the effect of speed as well as dimensions on the cost of transport. It was not difficult for Sir John Biles to make it quite clear that the cost of transport advances with increase of speed. He was able to establish that the augmentation in the cost of transport under such conditions would be much less in the longer than in short ships were the draught according to linear dimensions, and not arbitrarily limited. Assuming an increase in speed from 14 to 17 knots, he showed that the cost per ton-mile of running was increased, in the case of the 600-foot ship, 63 per cent, in the 700-foot ship 32 per cent, and in the 900-foot ship and the 1,000-foot ship 18 per cent. The same reduced rate of increase was notable in the advance in speed from 17 to 20 knots. In the case of the 700-foot ship the cost per ton-mile of running was more than doubled, for the 800-foot ship it was 50 per cent, for the 900-foot ship 30 per cent, and for the 1,000-foot ship 17 per cent greater than for 17 knots. It was pointed out further that it was exceedingly difficult to estimate what increased revenue was raised from passengers on account of augmented speed, but it seemed to Sir John not at all improbable that in vessels of 1,000 feet long and 20 knots speed the extra cost of carrying cargo might be more than balanced by the extra passenger revenue. But his conclusion was that such vessels would not be built with advantage unless the harbors were deepened to draughts corresponding to the depths of ships associated with economic length.

* Reproduced from *Engineering*.

Joints in Materials for Aircraft *

By Pegasus

One of the cardinal arts in aircraft making is the joining of material to material, and therein are fresh worlds for conquest by ingenuity and study. If it be a matter for astonishment that after centuries of engineering there is yet so much difficulty in effecting a simple and homogeneous union between dissimilar materials which have complementary qualities and therefore are often needed to work together—such as steel and bronze, steel and alloy steel, wood and metal, as well as latterly aluminium and brass, aluminium and steel—it is yet more noteworthy that for joining similar materials only recently have the welding processes been accepted as standard, and even then not without question; while the gluing, on which so much wood working depends, is a poor affair, incapable for the most part of resisting water and heat.

DANGERS OF HIGH TEMPERATURES.

Welding involves high temperatures which risk damaging the material. Such risk is minimized by specific precautions; but with aircraft, where failure leads to dire results, and where the factor of safety is appallingly small, very great care is necessary. The flame temperature is greatly in excess of the temperature required; no thermometer is employed; the skilled workman's judgment is the only clear safeguard, and that workman must be a beginner at some time. It is where one part is thick, and heats up more slowly than another which is thin, that burning is likely to occur. The safeguard lies in the fine pencil point of the flame which localizes the heating to the exact part intended. For brazing, the use of silver soldering is substituted with great advantage because of the easier temperature conditions; but even then there is so much risk that it is necessary to substitute pinning the tubes or parts together and running in soft solder, especially when the tubes to be joined are of an alloy steel, the intrinsic merit of which depends on its exact temperature treatment.

In the case of silver soldering and brazing, overheating being the one enemy, it is clear that a suitable bath, controlled by a pyrometer, will meet the case if the articles can be dipped; but with large structures (in aeronautics mostly lengths of tube) this would not often be feasible, and therefore the suggestion of employing a hot air blast adjusted by a thermostat so that it never exceeds the dangerous temperature of the alloy steel in question seems worthy of elaboration. It would be equally applicable to soft soldering and would not necessarily have the drawback of being slower, since as large a blast as desired of the heated air could be directed on the piece, while for most operations this air could, without detriment, contain the fumes o' the gas employed to heat it.

THE MAKING OF COMPOUND SPARS.

The compound spar made by joining together wood and metal—the metal being perhaps thin steel strip to take tension while the wood may be intended to take compression to give the necessary "substance"—has long been desired, but the hope has had to be deferred because no amount of screwing the two together can make them work together. The old chassis of *bois armé* of the early automobile maker was an attempt to get round the difficulty, but it was soon found, as indeed aeroplane makers who fill a steel tube with an ash filling will find, that a better result is obtained by employing the weight of the wood in the form of a slightly thicker steel tube or pressing.

Spars compounded of several pieces of wood are occasionally made, and here the screws are supplemented by good gluing as a rule, and so long as the glue does not get wet or deteriorate, a fair result is obtained. Still, glue is a poor substance for aeroplane wings to rely on, even in this indirect manner, owing to the exposure to which the craft are subjected.

Propeller screws are glued and doweled, and the glue is carefully protected by varnish or French polish; but such screws are short-lived, and the sooner the wooden glued air propeller is abandoned for something more permanent, the better. There exists as a trade secret a wood cement, used to a considerable extent in making the hollow masts and spars of sailing yachts, which is remarkably resistant to water, while certain classes of multi-ply wood sheets are joined between the plies by a cement which stands water fairly well. But even these joining materials are not permanently up to the full strength of the parts joined, and the exclusion of water must be aided by the use of good varnish if they are used on aircraft.

PROTECTION OF SURFACES.

A kindred subject is that of paints, dopes, varnishes, and protective deposits of metal for wood, steel and fabric. The protection of wires by grease, which is at present in vogue, is peculiarly detestable on account of the permanent adhesion of dust and grit to the greasy metal, the dirtiness in handling, and the labor of excluding the rust by replacing the greasy coat. The electro deposition of zinc by cold process and, perhaps, zinc spraying will find their way into aeronautical construction, though they have not yet appeared there. The protection of tanks from internal rust by such galvanizing or sherardizing will, as time goes on, doubtless enable steel tanks of welded steel to be employed in lieu of the copper tanks and the riveted tinned steel tanks now used, and with the arrival of such processes greater safety from fire will undoubtedly accrue to flyers who may make a rough alighting.

It is impossible to take even a cursory view of aeroplane details such as these, without being forced to realize how little time this new industry has had to assimilate, select, and evolve the processes best suited to its own peculiar and very stringent conditions. The standard varnishes used to protect the wood from rain are poor in the extreme, and reduce themselves to a couple of coats of unspecified shellac. Aluminium, perishable as it is, usually flies unpainted and unprotected. Steel tubes get a coat of nondescript black paint when they should be lacquered at least as well as is a bicycle.

In all these matters may be traced the hurry with which the new branch of technics has rushed along the path of progress. Men's minds are occupied with the broad questions—the main matters of aerodynamics, of strength, of weight-carrying capacity and speed range, of field of view. The world contains the knowledge of these other matters, but those in whose bosoms it resides are mostly unaware of the existence of aeronautics. It is the men with specialized skill who could, if they would, usefully come forward and infuse into aeronautics, whether by joining the industry or through the medium of its technical press, the seeds of detail progress, without which the permanent security of flyers and the continued success of designers cannot be expected.

* Engineering Supplement of the London *Times*.

Port Orford cedar of the Pacific Coast, recently tried as a substitute for English willow in the manufacture of artificial limbs, has been found unsatisfactory. While it is light enough, it is too coarse and brittle.

The Annual Aero Show in London—I*

The Present Status of the Art as Illustrated by the Olympia Exhibits

THE Fifth International Aero Exhibition should give the serious student of aeronautics much cause for thought. To say that the Show is interesting is to utter a platitude; but when we remark that it also indicates that much progress has been made, some further comment becomes necessary, as the advance in aeronautical science, except perhaps in one respect, is more real than is apparent. The exception we would make is in regard to the high standard of workmanship which is demonstrated in practically every machine exhibited; and, in this respect, too much praise cannot be lavished upon them, although it would be invidious to make distinctions. The reason for the comparatively little evidence of the progress that has been made is probably attributable to the fact that aeronautics has reached a stage of development when further advance along the lines upon which we are now working will be largely in regard to details, and as such will not be readily obvious to a casual observer, yet such progress will be by no means less material. As an illustration of this point, the wing construction on the Avro single-seater; the embodiment of the shield over the front of the *fuselage* with the propeller on the two-seater Bristol; the double-cambered planes on the Wright seaplane; and the design of bat-boat on the Sopwith machine, although not all novelties, may be specifically mentioned, but there are ample evidences of the presence of other improvements that will readily occur to the close observer. And as regards the future, it is not at all improbable that designers will do much to facilitate transportation and storage, as with the marked increase in span and size, difficulties in this respect have been greatly augmented during the past year.

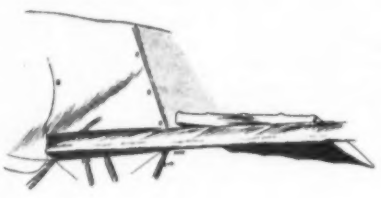
Of freak machines we may say that there are none. Not that there are no departures from what may be termed past practice, for the exhibits on the stands of Pemberton Billing and Perry Beadle differ slightly from that which has heretofore been usual, and their performances in practice should therefore prove of interest; certainly so far as the workmanship displayed is concerned, they leave nothing to be desired.

The distinct influence of military requirements upon design is clearly demonstrated; as, of the machines exhibited, no less than thirteen are specifically stated to be either scouting or fighting aeroplanes, eight of which are tractors and the remainder "pushers." On the fighting machines the propeller is always placed behind the wings, as would appear to be almost essential in order to obtain a sufficiently wide angle of fire for the gun, which is invariably placed in the front; but since the rotating propeller does not obstruct the field of vision to any marked degree, both types are used for observation purposes. That the requirements of the army and the navy should be so potent at the present time will be readily appreciated, since the commercial aspect of flying, except for demonstration purposes, which use is largely educational, has not so far attained any prominence; but with the increase in the proportion of, as well as the actual, useful load capable of being carried, combined with the natural tendency toward greater reliability, the possibilities of aerial transport have been brought much nearer. At the present exhibition there are no less than eight machines that are capable of carrying over 800 pounds, and sixteen have a useful load of 600 pounds or over, the corresponding figures being three and ten only twelve months ago, and four of the makes of machines then exhibited are not now being shown.

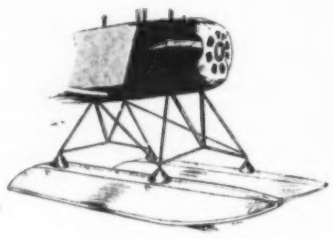
In steel construction there has not been the extensive use one might have been led to imagine would have been the case having in view the extent to which it is adopted in some Continental machines, although a greater tendency is exhibited to employ this material largely for the landing gear as is shown by the table given on page 265.

The methods of construction, used in assembling the various members of all-steel machines, are shown on the Vickers, the Clement-Bayard and the Nieuport stands, and are worthy of close study.

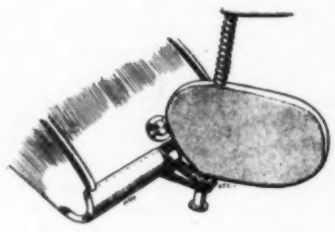
In regard to the engines exhibited, we have long passed that stage when lightness was the all-important factor, and now complete immunity from mechanical breakdown is demanded as an essential quality. Concerning those manufacturers who have been represented at previous exhibitions, we need say no more than this—that every make of engine has seen extensive employment on actual machines, not only in England, but abroad also. And as regards the newcomers, the Sunbeam has already been proved on the M. Farman at Brooklands and in tests conducted at the R.A.F.; the "Argyll" is built by a firm of motor manufacturers who have a big reputation behind them; and the "Stitax" presents a novel construction that would appear to have great possibilities. There are, therefore, at the present exhibition a number of different types of engines of British manufacture and of tried design, and although in the past they have not been the commercial success that one would have liked, great hopes are entertained that the Military Aeroplane Engine Competition will do much to stimulate this branch of the aeronautical industry.



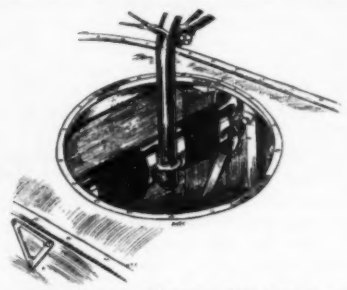
The air brake on the Avro scout.



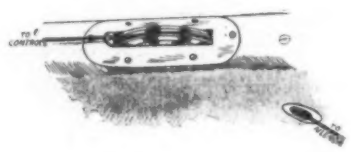
Chassis and main floats of the Avro seaplane.



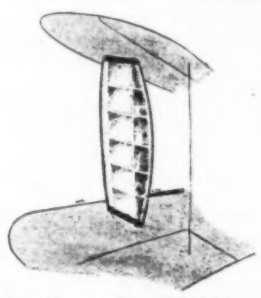
The water rudder on the Avro seaplane.



Detail of springing the floats on the Avro seaplane.

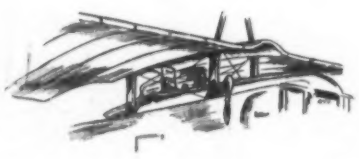


The aileron pulley in the Avro pusher.

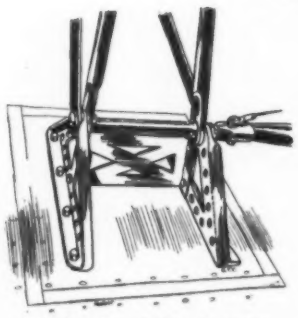


Streamline casing round the plane struts of the Avro scout.

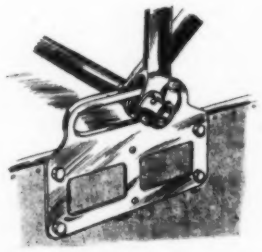
The water rudder on the Blériot hydro.



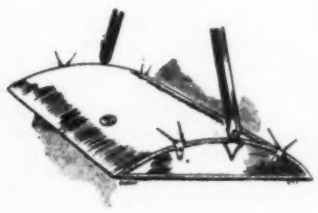
Method of mounting the wings on the visibility type Blériot.



Attachment of chassis forks to float on Blériot hydro.



Attachment of front chassis members on Blériot hydro.



The tail float on the Blériot hydro.

By Courtesy of *Flight*.

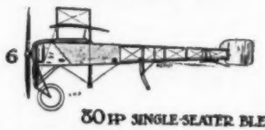
THE AVRO STAND.

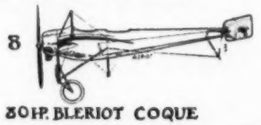
The Avro firm exhibits three machines, of different types, all representing considerable departures in design from previous models, while at the same time retaining the good qualities that have established such an enviable reputation for this enterprising firm. Keenly alive to the various requirements of the army and navy, Mr. A. V. Roe has designed three entirely different types, each for a different purpose, one being a military biplane of the pusher type, and built with a view to meeting the demand for a machine affording the observer an unrestricted view, and also possessing facilities for the mounting of a gun if desired. The second machine is a small, fast, single-seater, designed for scouting purposes while the third and last is a hydro-biplane. All three

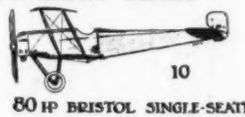
* Reprinted from *Flight*.

THE OLYMPIA AERO SHOW AT A GLANCE

Tables and Sketches Showing Principal Features of Exhibits







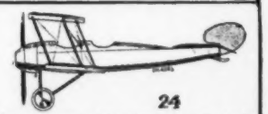
TABULATED PARTICULARS OF ALL THE AEROPLANES EXHIBITED AT OLYMPIA, 1914.

No.	Machine.	Country of Origin.	Type of Machine.	No. of Seats.	Speed. Maximum.	Speed. Minimum.	Dimensions. Span. Upper Plane.	Dimensions. Span. Lower Plane.	Dimensions. Chord.	Dimensions. Gap.	Areas. Main Planes. Upper.	Areas. Main Planes. Lower.	Areas. Elevator.	Areas. Fixed Tail.	Areas. Rudder.	Weight. Empty.	Weight. Useful Load.	Weight. Total.
					m.p.h.	m.p.h.	ft.	ft.	ft.	ft.	(ft.)²	(ft.)²	(ft.)²	(ft.)²	(ft.)²	lbs.	lbs.	lbs.
1	Avro	G.B.	Bi.	2	65	35	44	44	5'5	6	242	226	26	32	13	1000	800	1800
2	,, ...	,,	T.Se.	2	83	30	36	36	4'75	5'5	172	158	21	26	9	950	650	1600
3	,, ...	,,	T.Bi.	1	95-100	35-40	26	26	4'75	5'5	123	112	13	17	8	675	490	1165
4	Blackburn ..	,,	Mono.	2	70	40	38	—	7'0	—	252		19	30	9'5	900	600	1500
5	Blériot	Fr.	,,	2	72	—	34'2	—	—	—	248		—	—	—	770	618	1388
6	,, ...	,,	,,	1	—	—	29'3	—	—	—	194		—	—	—	618	309	927
7	,, ...	,,	Se.	2	68	—	26'3	—	—*	—	260		—	37'7	—	1120	550	1670
8	,, ...	,,	Mono.	2	75	—	33'1	—	—	—	205		—	—	—	770	606	1376
9	Bristol	G.B.	T.Bi.	2	62	33'5	37'7	37'7	6'06	5'9	215	205	14	15	8'6	970	695	1665
10	,, ...	,,	,,	1	95	47	22	22	4'26	4'26	161'5		—	—	—	617	340	957
11	Clement... ...	Fr.	Mono.	1	77'5	—	33'4	—	6'5	—	193		10'5	—	4'5	826	386	1212
12	Farman, H. ...	G.B.	Se.	2	59	—	51	31'2	6'2 (5'25)	4'9	310	160	22	40	15	—	660	—
13	Farman, M. ...	,,	Bi.	2	—	—	50'8	32'8	—	—	560		21'5	43	—	1320	660	1980
14	Grahame-White	,,	Bi.	2	80	42	37	35	5	6	183	175	23	26'2	15	1000	550	1550
15	,,	,,	,,	5	51	30	62'5	43'6	7'17	6'5	539	310	38	138	11	2000	1100	3100
16	Hamble River ...	,,	Se.	2	65	32	60	53	6	6	360	318	33	39	32	1300	1250	2550
17	Morane	Fr.	Mono.	2	70	50	37'5	—	5'6	—	200	—	16'1	—	8	870	617	1887
18	Nieuport ...	,,	,,	1	84	—	29	—	6	—	155'5		11	17	5'5	595	352	947
19	,, ...	,,	Se.	2	65	—	39	—	8	—	255		10'5	32'5	7	991	616	1607
20	Pem. Billing ...	G.B.	F.B.	1	50	—	28	28	5'625	5'25	153	140	20	31	12	750	220	970
21	Perry Beadle ...	,,	,,	2	64	—	35	23	6 (4)	6'5	200	85	6	25	11	950	—	—
22	Sopwith	,,	,,	2	70	40	54	44'5	6'75	—	600		30	40	10	2200	1000	3200
23	Vickers	,,	Bi.	2	70	40	38	38	—	—	400		30	35	13	850	850	1700
24	,, ...	,,	T.Bi.	2	100	45	25	25	—	—	270		14	25	6	600	600	1200
25	Samuel White ...	,,	Se.	2	72	35	63	59	6'5	5'6	735		30	36	12	2600	900	3500

F. = France G.B. = Great Britain.
Bi. = Biplane. F.B. = Flying Boat. Mono. = Monoplane. Se. = Seaplane. T. = Tractor.
Materials: A. = Ash. C. = Cedar. H. = Hickory. M. = Mahogany. Sp. = Spruce. St. = Steel. W. = Wood.

No.	Materials. Main Spars.	Materials. Fuselage.	Materials. Landing Gear.	Type of Landing Gear.	Suspension.	No. of Wheels or Floats.	Controlling Planes. Lateral.	Controlling Planes. Longitudinal.	Type of Fuselage.	Engine. h.p.	Engine. Maker.	Engine. No. of Cylinders.	Engine. Position.	Propeller and Position.
1	Sp. and A.	A. and St.	St., A.	CS., W.	Rubber	2 W.	Ai.	RE.	Nacelle	80	Gnome	7	R.	Avro R.
2	,,	,,	St.	F.	,,	2 F.	,,	,,	Square	80	,,	7	F.	,, F.
3	A.	,,	,,	CS., W.	,,	2 W.	,,	,,	,,	80	,, ‡	7	F.	,, F.
4	,,	A. and Sp.	A.	W., S.	,,	2 W.	Wa.	,,	Triangular	80	,,	7	F.	Blackburn F.
5	,,	,,	St., A.	W.	Springs	2 W.	,,	,,	Square	70	,,	7	F.	Integral F.
6	,,	,,	,,	,,	,,	2 W.	,,	,,	,,	80	,,	7	F.	,, F.
7	,,	,,	,,	F.	,,	2 F.	,,	,,	,,	80	,,	7	F.	,, F.
8	,,	,,	,,	W.	,,	2 W.	,,	,,	Coque	80	,,	7	F.	Levasseur F.
9	Sp.	,,	A. and Sp.	S., W.	Rubber	4 W.	,,	,,	Streamline	80	,, ‡	7	F.	Bristol F.
10	,,	,,	—	W.	,,	2 W.	Ai.	,,	Square	80	,,	7	F.	Integral F.
11	St.	St.	St.	,,	,,	2 W.	Wa.	,,	Triangular	100	,,	9	F.	,, F.
12	Sp.	A. and Sp.	,,	F.	,,	3 F.	Ai.	,,	Nacelle	80	,,	7	R.	,, R.
13	Sp.	Sp.	A. and St.	W., S.	,,	4 W.	,,	,,	,,	70	Renault	8	R.	,, R.
14	,,	A., H. & Sp.	St.	W.	,,	2 W.	,,	,,	,,	100	Gnome‡	9	R.*	,, (4 bl.) R.
15	A. and Sp.	A. and Sp.	A.	W., S.	,,	4 W.	,,	,,	,,	100	Green	6	R.	Lang R.
16	Sp.	Sp. and C.	St.	FF.	Springs	4 F.	,,	,,	,,	150	N.A.G. British	6	R.	Normale R.
17	A	A. and Sp.	,,	W.	Rubber	2 W.	Wa.	,,	Square	80	Gnome	7	F.	F.
18	St.	,,	,,	CS., W.	,,	2 W.	,,	,,	,,	60	Le Rhône	7	F.	Régy F.
19	W.	,,	—	CS., W.	Spring	3 F.	,,	,,	,,	100	Gnome§	9	F.	Integral F.
20	Sp.	Sp.	—	—	—	—	Ai.	,,	Boat	50	,,	7	F.	P. B. (3 bl.) F.
21	,,	M.	—	—	—	—	,,	,,	,,	60	E.N.V.	8	F.	Integral F.
22	,,	,,	—	—	—	—	,,	,,	,,	200	Canton-Unné	14	R.	,, R.
23	St.	St.	St.	W., S.	Rubber	2 W.	,,	,,	Rect.	100	Gnome	9	R.	Vickers- R.
24	W.	W.	,,	W.	,,	2 W.	,,	,,	Coque	100	,,	9	F.	Levasseur F.
25	Sp.	Sp.	Sp.	F.	—	2 F.	,,	,,	Nacelle	200	Canton-Unné	14	R.	White R.†

CS. = Centre Skid. F. = Floats. S. = Skid. W. = Wheels.
Ai. = Ailerons. R.E. = Rear Elevator. F. = Front. R. = Rear.
§ Standard—80 h.p. Le Rhône. * Chain drive. † Double camber. ‡ Monosoupape.



By courtesy of *Flight*.

machines are fitted with eighty horse-power Gnome engines.

The Eighty Horse-power Military Biplane.—This is of more or less standard design for this type of machine, as regards the general disposition of its component parts, but its designer has managed to incorporate in it numerous detail innovations. The *nacelle*, which is very wide and deep, is built up in the usual way of four ash *longerons*, connected by struts and cross-members of spruce, strengthened in places by steel tubes. Inside this *nacelle* are arranged the pilot's and passenger's seats, tandem fashion, the pilot occupying the rear seat, so that the observer has a clear view, while it is possible to have a gun mounted on the nose of the *nacelle*. The controls are of the usual Avro type, consisting of a vertical lever mounted on a transverse rocking shaft, from which cables are taken to the various control organs. The *ailerons* are operated by a side-to-side movement of the lever, while a to-and-fro movement actuates the elevator. A pivoted foot-bar controls the rudder.

Behind the pilot's seat, and just in front of the engine, are the gasoline and oil tanks, which have a capacity sufficient for a continuous flight of 4½ hours. The engine, which is mounted on double bearings in the rear of the *nacelle*, is almost entirely covered in by an aluminium shield secured to four tubular extensions of the *nacelle longerons*. At their rear extremities, where they converge, these extensions carry one of the engine bearers, the other being formed by a pressed steel frame mounted on the *nacelle* proper.

For a machine of the pusher type the chassis is rather unusual, it being in fact exactly similar to the chassis fitted to the Avro tractor machines. It consists of a single ash skid carried on two pairs of steel tube struts, and two wheels, sprung in the usual way by means of rubber shock absorbers attached to the *T* pieces of the wheel struts. In order to diminish head resistance, the shock absorbers have been enclosed in streamline aluminium casings.

The tail planes are similar to those of the tractor machines; the mounting of the fixed tail plane, however, being rather unusual, for the tail plane is not mounted on top of the tail booms, as is usually the case, but encloses the rear portion of the booms. In order to facilitate dismantling, the portion of the tail booms, which is inclosed by the tail plane, is hinged to the remainder of the tail booms by a joint, immediately in front of the tail plane, and the necessary rigidity at this point is obtained by cable bracing to the rudder post.

The main planes are of standard Avro type, except that the dihedral angle does not extend throughout the whole length of the planes, the central portion out to the first pair of struts being straight, so that only the outer portion of the wings are set at a dihedral angle. The method of carrying the *aileron* cables to the crank levers is rather unusual, and is illustrated by one of the accompanying sketches. It will be seen that the pulley has been placed inside instead of on top of the wing, the cable passing through a small opening in the lower surface of the wing.

The Eighty Horse-power Single-seater Scout.—This is perhaps the more interesting, since item bodies so many novel features. The chassis, *fuselage* and tail planes of this biplane follow standard Avro practice throughout. It is mainly in the design of the wings and their bracing that this machine is remarkable.

The wings have a very pronounced backward slope so as to increase the stability, which latter is further enhanced by the usual dihedral angle. In section, the planes are remarkable, in that they are absolutely flat on the under surface, while the upper surface is cambered in the usual way. This wing section is apparently one of the important factors for the very high speeds claimed for the machine, one of the others being the reduction of head resistance in the wing bracing. Only one pair of struts on each side separate the main planes, and a streamline casing around these struts further reduces the head resistance to that of a single strut on each side. The wing bracing is effected by two stranded cables running from the top and bottom respectively of the *fuselage* struts to a steel tube connecting the main spars at the point where these join the struts. Thus when the center of pressure travels backward and forward, the load is always taken by both spars through the intermediary of the steel tube connecting them. *Ailerons* are hinged to the outer trailing edges of both planes, while air brakes for pulling the machine up quickly on landing are formed by pivoting the rear portion of the wing near the body. For checking the speed of the machine on alighting, the pilot turns these air brakes by means of a lever until they are broadside on with regard to the line of flight.

The Eighty Horse-power Seaplane.—This is similar to the land machines as regards its wings and *fuselage*, but possesses some very interesting features in the method of springing the floats. These are carried on a structure of steel tubes, of which the outer members are bent downward inside the floats, where they are attached to another tube by means of rubber shock absorbers in the manner shown in one of the sketches. The opening in the deck of the float through which the tubular strut passes is afterward covered with a flexible cover made of diver's twill, so that although the floats are free to move several inches up or down, no water is admitted inside them.

The main floats, of which there are two, are of the non-stepped variety, and are also covered with diver's twill, which has been found to be more satisfactory than fabric, as it does not tear so easily, although it is undoubtedly somewhat heavy. The floats are divided by bulkheads into eleven watertight compartments, so that should one of them spring aleak, the remaining ones would still possess sufficient buoyancy to keep the machine afloat. The pilot's and passenger's seats are arranged tandem fashion, the pilot controlling the machine from the rear seat by means of the usual Avro controls.

A small float protects the tail planes against contact with the water, while a small water rudder, mounted just behind the tail plane on an extension of the rudder post, enables the pilot to steer the machine at slow speeds on the water.

Common to all the three machines is an extremely neat instrument board of Avro design, comprising altimeter, clock, compass, air speed indicator and revolution indicator, and all the machines are furthermore fitted with the Avro safety belt, the design of which is already known to the majority of our readers.

THE BLÉRIOT STAND.

Neatly displayed on the largest stand at the Show are the Blériot monoplanes—a tandem two-seater of the well-known type, a hydro-monoplane, and a single-seater military monoplane.

Total Visibility Type Monoplane.—This is probably the most interesting of these machines. The most characteristic feature is the disposition of the wings, which have been raised some distance above the *fuselage*, to provide an unrestricted view in all directions. The height of the wings above the *fuselage* is such that the rear spar, which is situated immediately in front of the pilot, is on a level with his eyes, so that there is only the thickness of the plane to obscure his view, and this can easily be overcome by either stooping slightly in order to look under the plane or by stretching slightly in order to look over it. For scouting purposes this arrangement would seem to be ideal, and we understand that the French Army has purchased several of this model, which was only adopted as a standard type following the success of the first experimental machine in the hands of French officers. One gathers that there is no appreciable difference between flying one of these machines and one of the standard monoplanes with the wings placed further down, so that with all the good qualities of the standard Blériot and the added advantages of total visibility, this machine should be a valuable addition to the list of military machines in England, where they will be built as soon as the factory at Brooklands is ready.

The engine—an 80 horse-power Gnome—is mounted between double bearings in the nose of the *fuselage*. Between the engine and the pilot's seat inside the *fuselage* are the two cylindrical gasoline and oil tanks, while an additional supply of gasoline is carried in another tank behind the pilot's seat.

Gasoline is forced from this main tank to the service tank in front by means of a hand-operated pressure pump on the right-hand side of the pilot's seat. Control is by means of a single vertical lever, mounted on a longitudinal rocking shaft, which carries at its rear end a sprocket, from which a chain passes to another sprocket on the lower end of the bottom pylon. The warping wires pass round a pulley on the same shaft as the pylon sprocket, and it will thus be seen that the "*clock*" has been discarded. This applies to all the machines exhibited and we gather, to all future machines.

The main planes are mounted on four short struts resting on the upper *longerons* of the *fuselage* as shown in one of the accompanying sketches. Owing to the raised wings the angle on the lift wires is particularly good, as is also the angle on the upper bracing wires, which are secured to a *cabane* of the usual type.

The tail planes are similar to those of earlier machines and they are protected against contact with the ground by a Malacca cane skid.

The Eighty Horse-power Seaplane.—This machine does not differ materially from the machine exhibited at the Paris Show. One of the chief alterations appears to be a shortening of the chassis by carrying the cross-member under the lower *longerons* instead of, as then, under the upper *longerons*.

The chassis is illustrated by the accompanying sketches and photographs, which are self explanatory.

The two main floats, of the non-stepped type, have been built by the well-known Tellier firm.

A small float protects the tail planes against contact with the water, and a water rudder mounted on an extension of the rudder post enables the machine to be steered when tacking at low speed.

The two seats are arranged tandem fashion as in the land machines, but appear to have been moved closer together, no doubt with a view to reducing the longitudinal moment of inertia. The same applies to

The Eighty Horse-power Tandem Two-seater, which otherwise appears to be similar in every way to those already in use in England.

The *fuselage* is of a similar construction to that of the Visibility type machine, but is slightly longer. The pilot's and passenger's seats are arranged in tandem, the pilot occupying the front seat, which is situated between the front and rear spars. The passenger's seat is immediately behind that of the pilot, while the trailing edges of the wings have been cut away near the body in order to give the passenger a better view in a forward and downward direction.

The chassis is of the usual Blériot type, but joins the body behind the engine instead of in front of it, as in the single-seater. The cylindrical oil and gasoline service tanks are mounted longitudinally inside the *fuselage* between the pilot and engine, while the main gasoline tank is carried in the *fuselage* behind the passenger's seat. In the machine shown, this tank is covered by a streamline cowl.

The tail planes are as usual, consisting of a fixed tail plane mounted under the rear end of the *fuselage* and braced by steel tubes, to the trailing edge of which is hinged the divided and negatively cambered elevator. The rudder is partly balanced by a portion of it projecting in front of the rudder bar.

A swiveling tail skid carried on a structure of steel tubes, and sprung by means of rubber bands, protects the tail planes against damage by coming in contact with the ground.

In addition to the three machines described above, there is shown one of the *aeroplages*, or sand yachts, which have attained no small measure of popularity in France, and which would provide quite a lot of sport if introduced at some seaside resorts. It consists of a framework of steel tubes, carrying the four wheels, of which the front ones have a wider track than those at the rear. On top of these transverse tubes are mounted two ash members running longitudinally from which the seats are slung. A steering column slopes backward to the driver's seat, and carries at its upper end an ordinary steering wheel, while at its lower extremity it has a bobbin, over which cables pass to the rear wheels via two pulleys on the ash members. The whole affair is very lightly built, and should be capable of a fair speed in a wind.

(*To be continued.*)

The Electric Emissivity of Matter*

Physical Investigations and Practical Applications

THE two lectures on "The Electric Emissivity of Matter," which Dr. J. A. Harker, F.R.S., of the National Physical Laboratory, delivered at the Royal Institution concern a subject of great theoretical and practical interest, which is at present in a decidedly controversial state. After the existence of free particles much smaller than the atoms, had been established, scientists possibly became too ready to explain new phenomena on electronic grounds. The critical study of the emissivity problem seems to indicate that a good deal of what is ascribed to emission of electrons might be accounted for by chemical reactions or affinities, just as the contact electro-motive force, so long upheld by some of the greatest physicists, is now largely believed to depend upon the different chemical affinities of the two metals in contact for the gas which surrounds the metals or adheres to them. The emissivity question, it will be seen, directly affects the efficiency of incandescence illumination, and the important practical developments in this direction have recently been recorded.

In his introduction Dr. Harker stated that it had been known for a very long time that the air, generally considered an insulator, became a conductor of electricity in the

* Report reproduced from *Engineering*.

neighborhood of hot bodies, and, indeed, that it always conducted to a very slight degree. Materials differed as to the relation between temperature and electric conductivity. Metals conducted better cold than hot, but in certain alloys (like manganin) the decrease of conductivity with heat was small. Most conductors of the second class (oxides, compounds) began to conduct only at a red heat, but mixtures did so at lower temperatures than the pure oxidic constituents—a property utilized in the Nernst lamps. Magnetite, many sulphides and carborundum conducted at ordinary temperature, and their conductivity increased very rapidly with increase of temperature. That glass also began to conduct at 200 deg. or 300 deg. Cent. was shown by the experiment of Warburg, in which two concentric test-tubes were used, partly filled with mercury; wire electrodes dipped into the two mercury pools which were separated by the glass wall of the inner tube. At high temperatures everything, in fact, conducted, and this effect was so general that good insulators for high temperatures were not known. On the other hand, Dr. Harker continued, it had been observed by Guthrie that an electrically-charged ball of iron lost its charge at a red heat if the charge were positive, and at a white heat, whether positive or negative. The phenomenon of electric emissivity had first been studied by Elster and Geitel, who placed a strip of the metal under examination in a glass bulb, and a metal plate joined to an electroscope above it. In these experiments much depended upon the gas in the bulb, its pressure, the dimensions of the apparatus, dust and impurities given off by the metal, etc. That the escaping electricity acted like the brush discharge from a point was demonstrated by an experiment due to Aitken. A wide horizontal glass tube was charged with moist air and joined to a pump. A beam of light was sent longitudinally through the tube; on expanding the air the moisture condensed to scattered big drops. But when the air was drawn over a hot platinum strip before entering the tube, the condensation took the appearance of a mist of very many fine drops, something escaping from the hot platinum forming the nuclei. This method of detecting an electric emission at relatively low temperatures has been used by Roberts in his recent work at Liverpool on the mechanism of the emission from platinum.

In the further study of these phenomena, the lecturer proceeded, J. J. Thomson had surrounded the metal to be heated in a vacuum tube by a cylinder of platinum connected with an electrometer, and had confirmed the previous observations as to the influences of the cleanness of the wires, the residual gas, etc. He found it very difficult to maintain a high vacuum while the wires were being heated, and had observed that the current flowing between the axial wire and the cylinder did not obey Ohm's law. Continuing these researches, however, O. W. Richardson (then in the Cavendish Laboratory) had arrived at the conclusion that these "thermionic" currents depended at saturation merely on the temperature according to the law

$$I = a\sqrt{\theta}\, e^{-\frac{b}{\theta}}$$

where θ was the absolute temperature, e the logarithmic base, and a and b were constants; this formula, Dr. Harker said, fitted the results obtained for many metals over a wide range. Another cognate phenomenon to be considered was the "Edison effect." When a metal plate was interposed between the two legs of the loop of an ordinary carbon incandescence lamp, and a galvanometer bridged between the positive leg or terminal of the lamp and the plate, currents up to 0.003 ampere were obtained, but hardly any current when the connection was made with the negative leg. Carbon particles were given off by the hot filament; but J. J. Thomson had proved that these particles were by themselves quite insufficient to account for the currents observed, and these considerations had led him to the conclusion, which had been confirmed by other researches, that the current was really carried by the small particles or electrons given off by all hot bodies, no matter of what material. The charge carried by an electron was 4.10^{-10} electrostatic unit. What that signified, Dr. Harker elucidated in the following way: Supposing we had no better current-detecting apparatus than the old-fashioned electrolytic voltameter, in which water is decomposed; if such a voltameter had been started in 1800 (when the Royal Institution was founded), with a view to measure the charge carried by a stream of electrons, 20,000 million electrons would have to come off per second up to 1914 to yield 1 cubic centimeter of hydrogen.

Dr. Harker then referred to the experiments which he had carried out in conjunction with Dr. Kaye. In these experiments the current merely served for heating, and all hot metals and carbon were found to emit positive particles at low temperatures, and while the impurities and gases in the metal were being driven off, and afterward at higher temperatures negative particles, the latter emission becoming very strong as the melting point was approached and melting was taking place. In the case of iron the emission began at 1,150 deg. Cent., and remained positive; in the other cases there was a reversal, influenced, as in the other instances, by the nature of the substance, the residual gas and its pressure, and to a strong degree by the impurities in the material. The lecturer then passed to the remarkable researches carried out in the laboratories of the General Electric Company at Schenectady by Whitney, Langmuir, Coolidge and other investigators, for the purpose of improving the efficiency of incandescence lamps with the aid of refractory metals. According to Richardson's formula, the electronic currents should at the temperatures reached in incandescence lamps attain considerable values. As the electric emissivity increased with the perfection of the vacuum, Langmuir had attempted to suppress the emissivity by working in some indifferent gas at ordinary pressure. He had succeeded under these conditions in running tungsten filaments several hundred degrees hotter with reasonable commercial life than the usual temperature attained in the present form of lamp *in vacuo*. In pure dry nitrogen there was little electric emissivity—or electric evaporation, as Prof. O. W. Richardson had called it in an address which he delivered at King's College, London, some time ago—while the light radiation at the higher temperature increased much, in spite of increased heat losses by convection and conduction. In these new lamps the current consumption had been reduced from 1¼ watt per candle to half a watt; the lamps burned for 1,000 hours, as others; the leads were profitably made of molybdenum. Dr. Harker exhibited one of these 100-volt, 2,000-candle lamps.

Instead of ten or twenty zigzag wires, these lamps, he explained in the second lecture, had only three or four, and the filaments were really very closely wound spirals of thin tungsten wire; the arrangement in spiral form was a very important feature. The ductile tungsten was said to be no more brittle than the glass bulb; the old tungsten wires made by squirting were very fragile, and such lamps should only be dusted with the current on, under which condition the metal was less brittle. Dr. Harker demonstrated that a large amount of oxides, nitrides, etc., could be expelled from a tungsten rod when heated up to its melting point. The experiment was made in a large glass receiver in nitrogen not specially dried. The vessel, on heating the rod with a large alternating current, became filled with a heavy fog. The improvements realized in Schenectady and elsewhere aimed at preventing disintegration of the filaments by adding the gas pressure, and suppressing the Edison effect or electronic emission. The latter suppression had, as mentioned, been possible with tungsten in a nitrogen atmosphere at ordinary pressure, but had not been possible with carbon, because the carbon disintegrated too rapidly. In these experiments, in order to obtain the highest possible vacua, they had at Schenectady jacketed the lamp, or other vessel to be exhausted, with a vessel which was also evacuated, lest at high temperature the soft bulb be crushed in by the atmospheric pressure.

By these systematic recent researches very considerable improvements had been effected in glow-lamps, as the following table exemplified, in which column A indicated the watts consumed per candle, B the number of hours run per Board of Trade unit, and C the cost, in fractions of a cent, of ten 16-candle lamps per hour:

	A.	B.	C.
Early carbon lamp	6.0	166	10
New carbon lamp	4.0	250	7
Metallized carbon lamp	2.5	400	4
Tantalum lamp	2.0	500	3-2
Ordinary tungsten lamp	1.0 to 1.25	800 to 1,000	1.6 to 4
Half-watt lamp	0.5 to 0.6	1,600 to 2,200	.4 to 1
Perfect lamp	0.10	10,000	.....

The light efficiency had been raised from 5 per cent. to 15 and 20 per cent, and that was remarkable, even in our days of electric progress. The figure for the perfect lamp was, according to Drysdale, the theoretical amount required for a lamp which turned all the energy into white light.

Passing to the other applications of the electric emissivity, Dr. Harker mentioned the utilization by Fleming of the Edison effect for wireless detectors, which were less easily upset by atmospheric electricity than crystal detectors and were largely used in high-power stations, and passed then to the remarkable Roentgen-ray tube, which W. D. Coolidge, also of Schenectady, described[1] last December. The apparatus consisted of a bulb with two diametrical tubular extensions. The cathode, in the middle of the bulb, was a spiral of a tungsten filament, 33.4 millimeters long (itself a closely-wound spiral of 0.2 millimeter wire), in five convolutions, joined to an accumulator battery by leads of molybdenum, welded and separately sealed in glass to leads of copper, which were again welded to platinum terminals. Opposite this cathode was an anti-cathode (or anode) of wrought tungsten, a cylindrical rod thickened at its end and provided with leads of molybdenum. The latter were supported and cooled in their tube by split-rings and rectangular strips of molybdenum. The first-mentioned spiral was surrounded by a cylinder of molybdenum, serving as a focusing device. The energy conveyed by the beam of electrons issuing from the hot spiral could be made so large as to fuse a hole into the anti-cathode, although the melting point of pure tungsten is over 3,000 deg. Cent. This bulb was said to have at 100 feet distance the penetrating power of an ordinary Roentgen bulb at 3 feet, and was, therefore, dangerous to work with at high power except under unusual precautions; but it offered great advantages. The bulb was not sensitive to changes in the gas pressure; the focal spot remained stationary, without inclining to wander about; the starting and running voltages were identical; the intensity was easily controlled in continuous runs for hours; the glass did not get hot, and there was no green fluorescence from the glass, probably because there was no bombardment by secondary rays from the target.

Returning then to the general problem, Dr. Harker showed some of the curves which Dr. Kaye and he had obtained with an apparatus in which a carbon rod, placed between two heavy blocks of carbon, was surrounded by a carbon cylinder, the blocks being ground down so that the cylinder could be fitted on with insulating material interposed. When the carbon rod was heated for the first time, the escaping impurities of the carbon (silicon, iron, etc.) produced a large hump in the emissivity curve, which was not repeated on renewed heating. That the emission per unit area for a given temperature of the rod was smaller with wider tubes might be due to the fact of fewer particles getting across the gap between the rod and cylinder. But the particles were not merely the electrons in the sense of Richardson's formula; gas particles probably attached themselves to the electrons. The impurities distilled out of the carbon in the early stages, when ordinary material was used, sometimes formed a cobweb of silica, etc., which disturbed the experiments, unless a current of inert gas was blown through the apparatus. These disturbing effects of gases were eliminated by conducting the experiments *in vacuo*, and the careful experiments of J. N. Pring and A. Parker, and the later work of Pring, strongly favored the view that the thermionic (or ionization) currents were due to some interaction between the carbon or its impurities and the surrounding gases, which involved the emission of electrons. Pring heated the rod or strip in a large bulb, and placed a collecting-electrode (charged to a potential of +220 volts for taking measurements) at some distance underneath the strip. Pring and Parker had found that the ionization of carbon was, at very low gas pressure, reduced to a much smaller order of magnitude (thousands of times smaller) than would correspond to Richardson's formula. Richardson had then revised his constants, which had been deduced from experiments with platinum; but the new experiments of Pring yielded micro-amperes where amperes should have been observed according to the modified formula. In these experiments Pring tried various gases, and found that the thermionic (or ionization) currents increased with the gas used (at very low pressure) in the order: helium, argon, nitrogen, hydrogen, carbon monoxide, carbon dioxide—which was the order of chemical activity between those gases and carbon. On re-admitting gas the effect increased, and the progress of the gas absorption and elimination could be followed by the ionization currents.

These conclusions, Dr. Harker continued, were in agreement with those at which Greinacher, K. Fredenhagen and H. Küstner had just arrived. They found that the photo-electric effect (the Hallwachs effect, or emission of electrons from clean metal surfaces when illuminated by light) vanished and failed when all gas was excluded. Küstner, we may add, made use of an ingenious apparatus, within which the zinc surface was scraped thousands of times with the aid of a steel knife in the course of an experiment, the escaping gas being removed by a Gaede molecular pump. According to these scientists and to R. Pohl, P. Pringsheim and others, chemical action probably played the main part in these thermionic and photo-electric effects, and Dr. Harker expressed the opinion that with many substances temperature was not alone decisive, and that chemical action had to be taken into account in dealing with thermionic currents. The effect of the space charge, as had been pointed out by Langmuir, was also important at the higher ranges.

Finally, Dr. Harker referred to the quite recent researches of Hale and King, of the Mount Wilson Observatory, in which they reach the conclusion that emission of swarms of charged particles might account for the powerful magnetic fields in the sun which certain sun-spot phenomena seemed to demand, fields of 5,000 units, unknown on the earth.

[1] *Physical Review*, vol. xi., page 409.

Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5.

Snapshot studies in lawn-tennis.

Snapshot Photography*

The Art of Working the Shutter at the Psychological Moment

By C. H. Claudy

To LEARN accurately how to take a picture of a moving object at the exact point in its movement we wish to take it, we must realize what factors enter into the problem. They are several in number. First comes the personal factor—that time interval in our brains or nerves or bodies, which occurs between our intention to do a thing and our doing of it. For they are by no means synchronous. Interesting experiments in a laboratory have been made which show plainly and graphically that the time between impulse to do and actual doing varies with different people, with knowledge or ignorance of what is to come, with different lights by which to see, and so on.

Thus, if a subject is told that he is to be blindfolded, and his hand is to be touched with a stick, and that the instant it is touched he must press a button, and the time of touching and time of button pressing are both recorded on what is known as a chronograph, there will be a distinct and fairly constant interval between the two times, for the same person, no matter how often the experiment is tried. But put the man's hand on a telegraph key, and touch it with a hot iron, when he isn't expecting it, and there will intervene a *longer* interval between touch and jerk of hand. Intention and *attention* reduce the time, in other words.

So attention to what you are doing is the first step in getting the object which is moving on the plate at a given time. You cannot do it so well while talking, looking at other things, or letting the attention wander—you must pay strict attention to the matter actually in hand.

Again, while the "reaction time" between seeing the object where you want it and pressing the button is usually the same for the same person under most conditions, the nerves *can* be trained to respond more quickly than they ordinarily would do. Nor is it necessary to use a plate or film every time this is done. Taking "shadow pictures" is good exercise for this sort of work—focusing the hand camera and following a moving image, and then pressing the button at the right instant, or pressing bulb if it has a bulb. As a matter of fact I am inclined to believe that this practice results in speeding up the "reaction time" rather through familiarizing the muscles with their work than from any education of the nerves, but the manner of the improvement doesn't matter much, so long as there *is* improvement.

The next factor to consider is the response-time of the instrument. To understand what I mean, recall to your mind that ancient boyhood game in which a long line of bricks are set on end, each close to the other. When the line is set up, you topple over the last brick. It knocks down the next brick and number two knocks over number three, and so on. The impulse travels from brick to brick until all are knocked down. Now, the longer the line of bricks, the longer it would take that impulse to travel from end to end of the line. It is the same in a camera. The mechanical impulse of button pressure or bulb pressure or lever release or what not takes a certain small interval of time to travel from arm to shutter, and the shutter itself has a small interval of time in which the inertia of the moving parts is overcome. In instruments of the reflex type there is the added time of the mirror, which must first fly up out of the way before the shutter is set off. The total time may not amount to more than the fiftieth of a second, although it often does, but even the fiftieth of a second in a train going 100 feet a second would mean a difference of two feet. In the reflex type of instrument the "lag," as it is called, is more apt to be a tenth of a second than a fiftieth, or somewhere between the two.

In instruments equipped with a bulb, the shorter the tube the less the lag—a tube expanding with the air pressure requires either greater pressure or more time, as it is added to in length, to transmit energy from bulb to valve.

These things are not matters of guess work, but of fact. Experiments in photographing fast trains by electrical contacts made by the train itself, show that it is necessary to have the contact made fifteen or twenty feet before the train reaches the spot where it is desired to have it pictured. This is not because the train travels fifteen or twenty feet while the current is overcoming the inertia of the magnet and release apparatus, and the spring of the shutter is overcoming the resistance and inertia of its moving parts.

Fig. 6.—The shutter caught the ball right on the bat.

I recall discussing all this with a young amateur once, who didn't believe that there was any "lag" in his nervous system. So he bet me a dinner at the country club that he could make a dozen snaps of men playing golf and tennis and show the ball in every one of his pictures. He tried it, and showed the ball in just one—and that was a picture in which the player had missed the ball altogether! It was a nice dinner, too. His trouble was that he waited until the club was just striking the ball, or the racket just about to touch the sphere, and then snapped—and by the time his shutter worked the ball had gone. Next time he tried snapping away, when the club and racket had a little chance for play—in other words, when they were yet several feet off from the ball, and this time had better results.

Now no man, I don't care how expert he is, can stop moving objects *exactly* where he wants them. He can't take a picture of a tennis player and get the ball just touching the racket, except by accident. He may get the ball within a foot or two of the racket before or after it is struck, but not right on it, except by a fluke. He may make a white mark on a railroad tie and say, "I'll stop the cow-catcher on that mark"—if the cow-catcher comes within six or eight feet of it, either side, he has done a good job. He may get a picture of a dog jumping over a fence, and if the dog is altogether one side or the other of the fence he will have been very successful; to get the dog with his middle exactly over the fence time after time is a practical impossibility.

An excellent way to practice this "stopping" of motion at any given place is to have some one throw big stones into a pool of water and photograph them as they are thrown. Take a dozen plates and attempt to get the stone (one) as it leaves the hand, (two) as it is half way to the water, (three) as it is just above the water, (four) as it touches the water, (five) of the splash just rising, and (six) of the splash subsiding, and see how many you get right out of two trials of six each. Then try a dozen plates all on one thing—say, of the stone just as it touches the water—and unless you have practised a great deal, you never get the stone at all the first six trials, but only a splash, or else the stone is so high in air as not to be considered as "near the water" at all.

I am accompanying this story with some pictures, not to demonstrate how well I can "stop" motion, but to show what can be done if you only keep at it—I do assure you that for every success I show you here of "stopping" anything at a given point, I have made in practice a dozen round failures—and I've been taking pictures for some time. But if you only do enough speed shooting you are bound to get the knack of allowing for the lag in your camera and the lag in yourself, in time.

Figs. 1, 2 and 3 are from negatives by C. R. Hough. Figs. 4 and 5 are negatives of C. R. Hough, which I made, and Fig. 6 is of my small boy.

Fig. 1 shows an attempt to get a jumping figure at the net in the act of hitting a tennis ball. But the picture was "previous," since the racket has not got around to the ball. Fig. 2 is "late," since the ball has been struck and is gone out of the picture, although the player is still in the air. Fig. 3 is about as perfect as such a picture could be, since the racket is just touching the ball. Mr. Hough made a dozen pictures at this one "sitting," of which Fig. 3 is the best. But, be it noted, Mr. Hough is a skilled athlete, an all-around outdoor man, and has naturally a quick "reaction time."

My pictures of Hough playing tennis are not so successful as his Fig. 3. *I* say this is because Hough didn't play good tennis—*he* says it's because I took pictures at the wrong time! However that may be, both of them show the ball, he having missed it both times. As a tennis ball travels nearly a mile a minute when struck hard, and as in both these pictures it is in front of the figure, I didn't miss getting it on the racket by much.

But for pure luck in getting a ball just exactly where you want it, I commend you to the little picture of my small lad whanging a ball with a bat! I tried to get him hitting the ball, and I did—once out of four times, although all the other three showed the ball. Of course, my shutter wasn't set fast enough and hence there is a trifle of motion, but there is the bat against the ball for all to see who look. Incidentally, he nearly decapitated me with that same ball, as it hit the ground and then barely grazed my head. My "reaction time" just did get my head out of the way!

This is an interesting department of photographic work, and brings its own reward in the shape of a brilliant success now and then among a multitude of failures.

*Reproduced from *The Camera*.

Blood Pigment and Chlorophyll*

Their Close Relation Points to a Common Origin of Animal and Plant Life

By Dr. O. Damm

AMONG the most recent biological achievements of general interest is the discovery of the intimate relation existing between the red pigment of the blood of vertebrates and the green coloring matter of plants. At first glance, the two pigments seem totally unlike, and it is certain that their functions differ exceedingly. The red blood pigment serves as an oxygen carrier, while chlorophyll builds up carbohydrates from carbon dioxide and water, under the influence of sunlight. Yet the two pigments are nearly related.

The preparation of chemically pure blood pigment is no longer a very difficult task. When blood is shaken with ether the pigment escapes from the red corpuscles into the surrounding liquid, from which most of it separates when the filtered liquid is allowed to stand for a considerable time at 32 deg. Fahr. The pigment is precipitated in the form of small crysta's, whose forms vary with the animal species from which they are derived. The crystals contain carbon, hydrogen, oxygen, nitrogen, sulphur and iron.

When easily oxidized substances are added to a solution of the red pigment, the pigment gives up part of its oxygen and assumes a purple color. In this condition, it is called reduced hemoglobin. When reduced hemoglobin is shaken up with air, it again absorbs oxygen and is converted into oxyhemoglobin.

Until recently it appeared impossible to obtain chemically pure chlorophyll, for every substance that was described as the pure pigment subsequently proved to be a decomposition product of chlorophyll. The recent investigations of Schunk, Marchlewski, Nencki and Willstaetter have brought about a great change in the situation. In particular, the researches of Willstaetter on chlorophyll are worthy to rank with those of Emil Fischer on the sugars and albumens.

Willstaetter succeeded in obtaining chemically pure chlorophyll in amorphous form. Like hemoglobin, it contains carbon, hydrogen, oxygen and nitrogen, but the elements sulphur and iron, which are constituents of hemoglobin are wanting in chlorophyll, which contains magnesium instead of iron. The formula of chlorophyll is $C_{55}H_{72}O_5N_4Mg$.

Until very recently it was assumed that chlorophyll contains phosphorus, and that it is therefore related to the lecithin group, but Willstaetter has definitely disproved these assumptions. The presence of iron in chlorophyll was long a subject of controversy. It is well known that iron plays an important part in the life of green plants. When a plant is cultivated in a liquid which contains no iron, its leaves turn white, or become chlorotic, in the language of vegetable physiologists, but they turn green when a minute quantity of iron is added to the liquid. Hence iron is absolutely necessary for the production of chlorophyll, but it forms no part of the chlorophyll molecule. Here is an important difference between the animal and vegetable pigments.

The fact that the iron of hemoglobin is replaced by magnesium in chlorophyll is explained, according to Willstaetter, by the opposite functions of the two pigments. He attributes the assimilation of carbon dioxide to the basic character of magnesium, which notoriously exhibits great combining power, even in complex organic molecules. On the other hand, iron is required for the analytic action of hemoglobin. Willstaetter, therefore, distinguishes two kinds of life—synthetic or deoxidizing life, which depends on magnesium, and analytic or oxidizing life, which depends on iron.

The chemist studies the constitution of a complex compound by breaking it up into simpler combinations until he finally obtains known chemical substances. By the action of dilute acids, hemoglobin can be divided into two components—a colorless albuminoid called globin, and a pigment called hematin. The globin contains all the sulphur, the hematin all the iron, of the hemoglobin, while the other four elements, carbon, hydrogen, oxygen and nitrogen, occur in both products. If hematin is treated with strong acids, it loses its iron, and is converted into a new pigment, hematoporphyrin, which has the chemical formula $C_{16}H_{18}N_2O_3$.

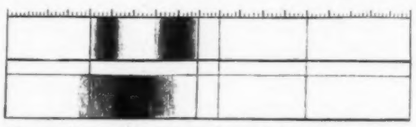
All of these pigments are characterized by distinct absorption spectra. Oxyhemoglobin shows two dark bands, one in the green, the other at the boundary between green and yellow, while reduced hemoglobin shows a single broad band in an intermediate position, as if the two bands of oxyhemoglobin had come together and coalesced.

The disintegration of chlorophyll is more complicated. According to Willstaetter's researches, nearly one third of the chlorophyll molecule consists of phytol, an alcohol of the formula $C_{20}H_{39}OH$, and chlorophyll is an ester of phytol and methyl alcohol with a tribasic acid, to which Willstaetter has given the name chlorophyllin.

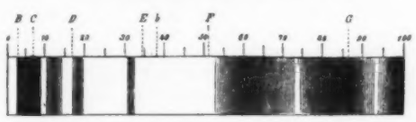
The absorption spectrum of chlorophyll shows numerous widely scattered bands, but by far the greater part of the absorption occurs in the red, and here, consequently, the maximum assimilation of carbon dioxide takes place. The light that is absorbed is the source of the energy which the plant requires for the process of assimilation.

Strong hydrochloric acid transforms chlorophyll successively into chlorophyllin, phylloxanthin ("leaf yellow") and phyllocyanin ("leaf blue"), and strong alkalies convert phyllocyanin into a red pigment, phylloporphyrin.

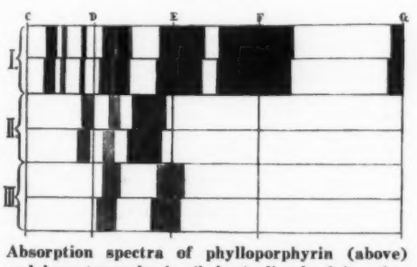
The chemical formula of phylloporphyrin, $C_{16}H_{18}N_2O$, is nearly identical with that of hematoporphyrin, and the two substances, one derived from chlorophyll and the other from hemoglobin, exhibit close physical and chemical resemblances. The most striking likeness, however, appears in their very complex absorption spectra, which



Absorption spectra of oxyhemoglobin (above) and reduced hemoglobin (below).



Absorption spectrum of an alcoholic solution of chlorophyll.

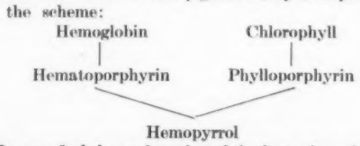


Absorption spectra of phylloporphyrin (above) and hematoporphyrin (below) dissolved in ether (I), hydrochloric acid (II), and zinc solution (III).

are identical except that each band is a little nearer the red end in the spectrum of hematoporphyrin.

Deoxidizing agents convert hematoporphyrin into hemopyrrol, a compound of carbon, hydrogen and nitrogen. The same compound can be obtained from phylloporphyrin by the same process. Both hematoporphyrin and phylloporphyrin, when heated, evolve vapors which smell strongly of pyrrol (C_4H_5N) and give a deep red color to spruce chips saturated with hydrochloric acid.

Hence there can be no doubt that chlorophyll and hemoglobin have the pyrrol nucleus in common, and that chlorophyll, the great synthetic agent in life, is nearly related to the great analytic agent, hemoglobin. The genetic relation of the two pigments may be represented by the scheme:



Here we find the explanation of the fact, often observed by physicians, that in some cases of anemia the increase of red blood corpuscles is promoted by giving the patient large quantities of green vegetables, in addition to preparations of iron. In this way, the organism acquires the pyrrol nucleus needed for hemoglobin.

The recent researches on chlorophyll and hemoglobin possess great biological importance. The Darwinian theory of the origin of species is based upon the variability of forms under the influence of varying conditions in the struggle for existence. The diversity of organisms is expressed, however, not only in external form, but also in the chemical nature of the constituents of living cells. These constituents determine the character of the vital processes, which in turn determine the forms of the cells, their differentiation in function, and the structure of th organs. Hence, knowledge of the chemical composition of cells and the chemical nature of their metabolism is as essential as knowledge of external forms to the comprehension of the history of evolution. Regarded from this point of view, these researches exhibit great and general scientific interest.

According to the investigations of Winogradsky, certain bacteria (*Nitrosomonas*, *Nitrosococcus* and *Nitrobacter*) possess power to build up organic matter from carbon dioxide, as is done by plants which contain chlorophyll. These bacteria, however, assimilate carbon dioxide in darkness, if they are supplied with a sufficient quantity of ammonia, which they oxidize into nitrates, for which reason they are called nitrifying bacteria. The energy produced by the oxidation of ammonia takes the place of the energy that green plants absorb from sunlight. The nitrifying bacteria are among the oldest inhabitants of the earth. Bacteria in general feed, like animals, on complex albuminoid compounds.

The quantity of carbon dioxide assimilated by the nitrifying bacteria is relatively minute. Chlorophyll was required to make the process complete, and to satisfy the requirements of organic evolution. In a much later period of the world's history, hemoglobin was evolved from the mother substance of chlorophyll, in the bodies of vertebrate animals. Thus, the recent researches on chlorophyll and blood pigments point to a common origin of vegetable and animal life.

The Loaf of Bread

THE widespread propaganda for the purity of the food and drug products of this country has resulted in the necessary attempt to standardize all articles which enter into these categories. In the case of certain familiar materials like sugar and coffee this has not involved any formidable difficulties. The question as to what constitutes mince pie, on the other hand, has aroused storms of claims and counterclaims on behalf of the recipes of different regions and generations. Like numerous other illustrations which might be cited, this experience has served to call attention to the really great diversity of our food concoctions and the pardonable laxness in the use of current terms that appear in the American menu. One may well apply here the proverb: *De gustibus non disputandum est.*

It might be expected that so common an article of diet as bread would exhibit some uniformity of composition. Yet the chemist of the Connecticut Agricultural Experiment Station reports that two hundred loaves of bread, representing the product of seventy-nine Connecticut, one Springfield, (Mass.), and three New York bakeries "showed wide variations in all their ingredients." For example, the moisture content ranged from 27 to 40 per cent, so that in some instances the bread contained excessive amounts of water. The fat present also showed a wide range, from 0.08 to 4.37 per cent. These differences are largely due to the methods of the bakers. In some cases only flour, yeast and salt are used, while in others, milk, butter, lard and sugar, either alone or in combination, are employed. The variations in fat are also due in part to the fact that in the process of baking a part of the fat is destroyed. In some samples the amount of fat found is much lower than could have resulted from the use of any brand of flour.

A comparison of the variations in a five-cent loaf of bread is interesting in other directions also. The actual amount of dry matter per loaf in the Connecticut samples ranged from 7.9 to 12.7 ounces; the average weight of the loaf in nine cities ranged from 12.9 to 15.2 ounces. The cheapness of the three and four-cent loaves indicated a real saving, as far as quantity is concerned, because the decrease in price was greater than the decrease in weight. As the price of a loaf of bread has remained stable at five cents, while the cost of the ingredients has increased, changes in the real cost of the nutrients of bread must be sought in the changes of size or composition of the loaf. According to investigations made in New Jersey in 1895, loaves costing four and five cents, weighed from 12.7 to 21.8 ounces, average 16.4 ounces. In 1895 in New Jersey, 58 per cent of the five-cent loaves weighed over 16 ounces, and 83 per cent over 15 ounces, while in 1912 in Connecticut only 7 per cent weighed over 16 ounces, and only 16 per cent over 15 ounces. Assuming similar conditions in these two states, the average weight of the five-cent loaf has shrunk since 1895 from 16.4 to 14 ounces, or 15 per cent. When all has been said, observes *The Journal of the American Medical Association*, the student of nutrition will doubtless still remark that bread is cheap at any price.

*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Prometheus*.

Colossal Waste Due to Bad Municipal Engineering*

Paying for Space Economy with Human Life

By Bernard J. Newman

It may be an old fashioned idea or it may be new, you can characterize it as you will, but the fundamental purpose of all municipal government and the activities set in motion by it, is the benefit of the public. Social instincts draw men together in towns and cities, economic laws set the limits of their personal freedom of choice in the manner of living there, community interests tend to centralize their form of government, but the indisputable fact is that the welfare of the public as a whole alone justifies the expenditure of public funds, the size of the tax rate, as well as the regulations, call them laws or ordinances or department rules, that control their conduct toward each other and toward the whole. I am taking this as a thesis to-night, though I have hidden the subject under the more sensational title of "Colossal Waste Due to Bad Municipal Engineering."

There are wonderful possibilities in this more sensational subject. For example, one might treat it along the lines of defective engineering caused by graft: the leakage of materials connected with the construction of a filtration plant. Or one might expose the defects of construction of a type similar to that mentioned in connection with the construction of the concrete walls at League Island Park, or the Passyunk Avenue Bridge of the N. E. Boulevard. But the waste to which I refer is not centered in the graft extracted from the performance of the improvements themselves. This latter is valuable to some parties for campaign material or to the newspapers for sensational headlines to stimulate larger sales of special editions. Occasionally it is valuable to shock prominent citizens into voting, but it has no place in this analysis.

What I refer to to-night are the municipal plans for the physical city together with the additions, alterations and amendments placed to them from time to time, without taking thought as to how such plans are related to each other or to the whole, or how they act upon the people who inhabit the physical city, whether the amounts apportioned for them are, as compared with city needs, apportioned equitably, or whether they are apportioned without vision and, hence, are unbalanced; whether they tend to develop the best living and working and pleasure conditions for the people, or whether they are designed to yield a profitable return for special interests whose invested capital and profits might be jeopardized or enhanced; and lastly, whether they are projected in the light of modern scientific knowledge, demonstrating the effect of environmental influences upon public health, morals and comfort.

In all this, the central figure is man. It is he that is the object of consideration, and for his welfare are all things justified. A peopleless city is valueless. The cliff homes of New Mexico cannot stir up an appropriation from Councils (though perhaps they might get into an appropriation bill in the State Legislature). No one thinks of improvements in connection with them because there are no human beings living there to give an excuse for the projection of the improvements. In Philadelphia matters are different. If an appropriation is asked for water mains it is because such are proposed for utilitarian purposes; if sewer pipes, that they may be of service. If streets are laid out and built they are for use. If parkways and boulevards are projected, the only justifiable excuse is that they may facilitate traffic, or become objects of beauty and pleasure for the community. The same is the case whether it is a new public library, art museum, convention hall, high school or what not. The justification behind them all is that they minister to some public use, answer some public need.

In the consideration, therefore, of municipal improvements the important question is, in how far do they benefit man and in how far do they interfere with his best interest? If they are for him, then there is only one consideration of prime importance: namely, do they help him or do they hurt him, either by withholding from him other and more important improvements or by fastening upon him problems he did not previously have, and which in themselves seriously handicap him? This is not a radical requirement, though it is fundamental, and in reality furnishes us with a measuring rod whereby we can tell the real value of municipal projects past and future.

Making use of this measuring rod, let me place before you certain municipal projects that have been and still are costly. We will begin with the street layout. When Penn planned the city of Philadelphia he adopted the checker-board system; large squares with deep lots; narrow streets, save in exceptional cases where, as with Market and Broad, he made wide thoroughfares. Here and there was a radial street, but the whole had little resemblance to other than the ordinary straight layout. Upon these streets, houses were erected so that there might be "a wee bit of green grass" in front and back. Time, and the influx of population, and the wanderlust that has mitigated the development of the ancestral hall in this country, all became factors in changing the earlier developments in the character of their occupancy. The "first families" who settled there moved farther out as the population became more numerous. Land values increased. Taxes were levied on properties intended for dwellings at rates beyond any possible yield on a business basis. One of two things had to be done. The houses had to be diverted from their former use as single family homes to multiple homes, or the extra land in the rear had to be developed so as to return an income. The city had no system; laws governing the subdivision of land were not known. Hence the large lots were opened for building. In some instances the owners cut through a street or streets, portioning the blocks into two or three smaller blocks. These new streets were often joined by cross streets none of which were over 30 feet in width, while many were only 14 feet wide. Of course, houses were built upon all, and a congestion of buildings created. In numerous other instances, however, these streets were not cut through. The different owners simply used their back lots and erected the small alley house of which we have so many thousand. Some of our city blocks in the old areas have from 25 to 50 per cent of the houses wholly within the block and without any street frontage. With this development established in hundreds of blocks and with thousands of small houses having one room to a floor and being three floors high, with no yards, often only a tiny alley from 4 to 6 feet wide, at times not even this, but 8 or 10 dwellings facing a common court, the congestion of population to the land increased. Of course, the type of population that would rent such abodes was lower in the economic scale than that which would rent the street houses, and the problems of public health and public morals were thereby intensified; to what extent I will point out later.

We, of the city, are fond of contrasting ourselves and our conditions of living with other cities, and always to our own favor. We breathe many a sigh of relief that we are not as New York is. Fortunately, indeed, for us we have not New York's tall tenements. *Nevertheless, we have congestion of population and building congestion that destroys privacy* and assaults our poor in as many vicious ways as do the tenements of New York. Remember the width of our streets in the older parts of the city, then remember what I have said about the subdivision of blocks, the lack of yards, the alleys and courts. The waste here, due to bad municipal engineering, is economic as well as civic. "The river of national health must rise from the homes of the people and from each individual home," says Dr. Richardson, the English specialist. If the home is lacking in the fundamental essentials for health, that is, proper ventilation, sanitation, living and playing space, if it is overcrowded, if the light is poor so that the occupants are living in gloom all the day, if there are dozens of other homes of like character nearby, what chance has any one of them to become a source of purity or strength? It is absurdity reduced to its most absurd limits.

But there is another side of this. Such subdivision of the land so as to build back lot houses *has been legally stopped. The laying out of streets on a narrow basis without any precautions* to control the use of such streets or the permanency of the type of occupancy is still going on. The minimum requirements for the open areas in and about buildings have been changed so that instead of permitting a family to share an alley with the adjoining families for a playground, the law now says each house shall have at least 144 square feet of open space, but the builder can put it in a strip running along the side and back of the house in any width he wishes. Some have made this strip 5 feet wide. The neighboring owner has built clean up to his property line, thus producing as vicious a type of an alley as anything perpetrated in the olden days. It is entirely feasible to house a population, under our present building code, of 300 people, in small dwellings, to the acre, including streets in the estimate. If recourse is made to the tenement type, building only four-story houses, we can easily create a density of 1,000 people to the acre. *These evils are visionary, do you say?* I imagine those early settlers who were told they were misplanning the city, also said the evils we now have were visionary. We do not know the results, we only know the possibilities. If the possibilities are bad, the engineering that planned them is faulty. For if I understand the science of engineering, it is to enable projects to be accomplished without mistakes and for beneficial results. In short, we have not to-day learned the lesson of the past, but are blindly rushing forward to the reproduction of similar evils in the future.

As I started to say a while ago, there is another side of cost to all this changing in the character of neighborhoods and of the occupancy of buildings from a higher to a lower grade. It brings its burden upon the rates in the increased taxes, the depleted civic interest, the debased manhood and citizenship, but it also necessitates economic costs few people consider. Narrow streets with increased congestion of population means increased use of streets, larger demands upon the drainage system, increased facilities for water supply to accommodate the people of the neighborhoods unless we are satisfied to give only one spigot to a court of 4, 5 or 15 houses. Under normal needs with the increase of population there comes an inadequacy of municipal facilities. All the provisions previously installed in these lines have to be enlarged or duplicated. If this is not done, there is an inadequate service. This is well illustrated in the water supply for southeast Philadelphia, where, during portions of the day, the pressure on the mains is insufficient to force water to the third floor of some of the tenements. Moreover, there is an additional extravagance. Traffic conditions change. The amount of it overflows the space for it. The speed is reduced; the danger from it is enhanced. Time is money in business, and especially where labor is purchased. If it takes an ordinary dray an hour longer to deliver its load on account of the heavy traffic in the streets that were not intended for other than light traffic, then the cost of that delivery is increased 10 per cent. If it takes the grocer, or any other tradesman, a half hour longer to get about because of the street conditions, it adds that 5 per cent to the cost of the goods, in the figuring of which delivery charges are considered. Then again, the congestion of traffic caused by the congestion of population intensifies the wear and tear of the pavements, for it concentrates instead of spreads the burden of it, and the repair gang is called in more frequently. You may say these are small items, but in every budget it is the small item that ordinarily escapes, and that makes the bills soar. The point I am making here is this: With the failure of the city to lay out its streets on a scientific basis, and with the attendant failure to regulate the changes in the character of the occupancy of the neighborhood, these evils creep in, and the cost to the city attendant upon the transition fastens a burden upon the people in added taxes, in economic prices, in health, morals, and personal fitness.

It would seem, therefore, that the layout of the city streets, affecting, as it does, the economic use of the city blocks, would *be a proper field for scientific municipal engineering,* and that the mistaken plans now fixed by ordinance over large and undeveloped areas within the city might be subject to special study and revision; while, at the same time, the area requirements for open space about buildings should be changed so as to protect the future against the duplication of the mistakes of the past.

Then, again, and let me cite these rather rapidly, there is the need for an underdrainage programme for the city. To meet the needs of a city growing about 25,000 people a year there must be a definite plan so as to anticipate developments and to prepare the streets below the surface before the street above the surface has been completed. How inadequately this has been done is illustrated by the simple statement that there are approximately 42 miles of streets in the older parts of the city that are without sewers. When you remember that nearly all of these are wholly or partially built up, and that the failure to lay pipes is responsible for two of the most pernicious of nuisances: surface drainage and the privy vault, you will appreciate the waste in human life, health, and well-being thus caused. For be it remembered that, as Mr. Vogleson, of the Health Board, says, "The death rate of the city is directly related to its sanitary condition." E. F. Smith, in an early book on the subject, calls attention to the fact that when a city has been underdrained the death rate has dropped and never again climbs to the former heights. If this is the effect of underdrainage on a city as a whole, it must likewise be the effect upon the city in all its parts. Where the lack of proper drainage exists, the city is to that extent exposing the people there to disease risks. The skeptic can easily assure himself of the truth of this if

* Paper read before the Engineers' Club of Philadelphia, and published in its *Proceedings*.

he will go into the obnoxious conditions produced by the privy vault which Smith, in his "Filth Diseases and their Prevention," states their pollution of the air is a chief means of spreading some of the most fatal diseases. It is not a far cry from the filth and the disease germs in the vault to the same within the home when fly breeding time is with us.

Further, when sewers are laid in the older areas there seems to be no definite plan. Several blocks will be without drainage, and yet ordinances will be introduced into Councils for sewers that skip a street or two and provide pipes for alternate blocks, with the result that one row of houses can underdrain but the next row cannot. The underdrained row will still have to put up with the filth caused by the surface flow and the vaults of the row not underdrained. Moreover, there are many streets that have been opened for a score or more years, but the beds of which have not been dedicated, thereby delaying the placing of sewers. A full work for the city would include a thorough study of conditions so that all occupied streets should be placed on the city plan; all streets should be legally opened; all legally opened streets should be provided with sewers; and all streets toward which building operations are tending should be opened and sewers laid at the time so as to reduce the actual cost of the work to the city. We are going to see a stimulus in new buildings in new areas when the subway goes in. Advantage should be taken of this opportunity to prepare the section beforehand.

Delayed improvements are always more expensive. Especially true is this when the improvements are of a sanitary character, and their delay affects public health or augments the processes of deterioration that are constantly active in the physical life of the community—processes, by the way, that seriously influence the moral and civic life of the people.

Without attempting to enumerate the various forms of public improvements that have their reflex action so injurious to man when they are not planned with an eye to their possible effect, let me cite a few that are usually incompletely planned and result in the creation of detrimental conditions or intensify such conditions when they already exist. We all favor parks and playgrounds and boulevards. They are essential to the development of a city. Yet we have provided them here in Philadelphia as if they were an entity in themselves. The situation along the line of the proposed parkway is typical. Here the city has condemned dwellings of all sorts and conditions. It has removed some that were exceedingly bad and others that were good. At a modest estimate it has taken the homes of from 1,500 to 2,000 people. For those of comfortable circumstances the removal did no harm, for they could find plenty of houses as good as the ones they had occupied, for rent or purchase. But the poor were sent into the congested sections to intensify the congestion. They had to go where they could get rooms for the rent within their means. Thus the city took the homes of the poor to make a fine boulevard, but it did not consider the added problem it forced upon these poor and others in similar circumstances. What I am seeking to emphasize here is that a satisfactory city programme will never contemplate improvements without counting the cost and making provisions for those whom the improvements displace. The renting of houses is subject to the law of supply and demand, and the demolition of any large number of homes without the erection of others to replace them throws the balance over against the man who pays the rent. This means eventually increased rents, smaller apartments for the very poor, and all the evils that attend overcrowding.

In like manner all improvements of whatever nature have their effect for good or for evil upon home life. The location and size of factories, store houses, terminals, wharves and docks, steam railroads, transit lines, tunnels and elevated, centers of commercial life, all affect the environment of man and determine for him to a large extent the health opportunities of his home.

This survey has necessarily been hasty. I do not pretend it is more than an index of causes that rightly co-ordinated develop a community by being considered as separate units without relation to each other and to the dwellings of men produce the evils we find so plentiful in all our large cities, and all too plentiful in the city of Philadelphia.

You ask what is the cost of bad housing to the people of Philadelphia? I very much fear I would have some difficulty in answering that question off-hand, for it would require an amount of special research that my time just now would not justify. You see we would have to approach an answer from the health side, the economic side and the moral side. So far as I have been able to ascertain no one has gone into any of these aspects of housing of Philadelphia so as to be able to give an answer at all approximating accuracy. It has been worked out to a limited extent, just enough to know the cost is tremendous; but the full sum has not been determined. Take, for example, the health side of the question. The last published reports indicate that there are approximately 9,000 preventable deaths a year in the city of Philadelphia. Now we know a preventable death is a death from a disease that should not have had a foothold here; that is, the disease is a so-called filth disease. It is common knowledge that filth diseases are preventable, and they only continue because communities permit conditions to exist that cause them. Get rid of the conditions and the disease will, in a large measure, be eliminated. Take tuberculosis as an instance. How long would it continue to be a scourge if air and sunshine were let into all the homes of the people? And if the houses that year after year go on making their victims were cleansed out thoroughly or else vacated and forced to stay vacated until they were thus cleaned? When our Commission was preparing the Heidinger Housing Code, we made some studies of tuberculosis records. We found one house from which, during the last five years, 14 cases were reported. Many houses had a record of 7, 8 or 9 cases during the same period. These were all new cases and in different families. As is to be expected, these records were taken from the old parts of the city where the houses are built more closely together and where sunlight and ventilation are often luxuries in alley homes. Some years ago Dr. Flick made a more extensive study of tuberculosis as it is related to the housing conditions of the people, and his published records show the frequency of occurrence of this disease in certain houses to be abnormally large. Approximately, during the past five years 3,000 people each year, in Philadelphia, have died from this one disease. There are now at least 10,000 people with well-developed cases in the city.

It is unfortunate that very little attention has been paid to the collection of exact data upon which to make an accurate study of the effect of conditions upon public health in this city. The Health authorities have not gone into this analysis, and private persons have not the facilities to do so. In any scientific programme for the protection of public health such data are necessary, for without it the efforts to stamp out contagion must necessarily be more or less of the nature of guess work.

Equally important also are such data as aids to law enforcement. When scientific studies are made, tracing the relationship between cause and effect so that even the greenest novice of a juror or magistrate can see it, the excuse for noxious conditions to remain is removed. Other cities have made such studies, and it is upon their work we have to depend for the scientific statement of the consequences in ill health from bad housing.

Data have been tabulated of the general effect of city life upon public health both in England and in Germany. Horsfal, in England, states that only 1,000 Manchester men out of 11,000 examined were physically fit for the army at the time of the Boer war.

Prof. Pasadowsky, in Germany, reports a study of 621,210 German soldiers and sailors. Notwithstanding the enforced service of all young men in the Empire physically fit for duty, yet two thirds of the enrollment of both divisions came from the country districts. This difference becomes even more strikingly pronounced when it is remembered that there are 5,000,000 more in the cities than in the country districts.

Measured by army standards of physical well-being, the effect of congested community living, under adverse circumstances, is wearing on men. But let us bring this record down to the areas in which the large proportion of bad housing conditions are to be found, and see what we find. Overcrowding or congestion is a large factor in increasing deaths. For example, Dr. Newman, Medical Health Officer for Finsbury, reported the ratio of deaths to 1,000 population in four-room houses, in his district, to be 6.04, while the ratio of deaths for one-room houses was 39. That is, under the more subnormal, congested living, over six times more persons died each year than in the more normal conditions. In Glasgow, a few years earlier, figures not quite so startling were unearthed. The one-room homes had a death rate of 32.7 per 1,000, while the four-room homes had only 11.2.

Then again, take the records of the houses as regards block ventilation. A study of 13 cities in West Yorkshire, England, showed an average death rate in houses open on two sides to air currents of 15.51 per 1,000, while those houses built back-to-back had a death rate of 17.94 per 1,000 persons. The record for pulmonary diseases, excluding phthisis, was equally enlightening. Here the comparison was 3.6 in the well-ventilated houses and 4.44 in the poorly ventilated houses.

These figures are especially interesting in that in this city we have many back-to-back alley houses improperly ventilated and lighted. The contrast for the same disease in the crowded houses in London is likewise extreme. Thus one-room houses have a rate of 3.4 as contrasted with 1.4 in three-room houses. While for other respiratory diseases the rate for the one-room is 8.3 as compared with 2.9 for three-rooms.

Perhaps as good an illustration of the handicap bad housing puts upon the public is presented in the figures of development of the school children in Glasgow. In this study the school authorities took records of 78,857 children between the ages of 5 and 18 years. Boys living in one-room houses weighed 52.6 pounds and were 46.6 inches high, while those in four or more rooms weighed 64.3 pounds and were 51.3 inches high. The effect upon the girls was even more striking. Those living in one room weighed 51.5 pounds and were 46.3 inches high as contrasted with those in four or more rooms who weighed 65.5 pounds and stood 51.6 inches high. The school authorities, commenting on these figures, say the difference in so many homes cannot be due to accident and put the blame squarely upon the environmental influences that are so bad.

Now it may be claimed that there is a multitude of other causes producing these defects, and housing is not so great a factor as it would at first seem. It is not the only factor. In other words, the chances for a baby to live were more than twice as good amid the good housing conditions as amid the bad. Even more effective a presentation of the differences is found in the Liverpool figures. In one large area where the old back-to-back houses and rookeries were torn away and, in their place, 2,663 new houses were built with opportunities for light and air afforded for each room, the death rate declined from 60 to 27 per 1,000; tuberculosis from 4 to 1.9 per 1,000; typhoid fever from 1,300 cases in 1896 to 200 cases in 1911. The change was not due to a new population moving in, for over 70 per cent of the old population were rehoused. In Glasgow, where a similar rehousing took place, the death rate declined in the new housed areas from 43.7 to 26 per 1,000. Similar testimony from many sources can be cited and can be sifted to trace the responsibility to bad housing.

The point of it all is simply this: Are we, as citizens, intelligent enough to work for public health along scientific lines? Or are we so short-sighted in our health policy that we are content to go on caring for and curing the victims while we neglect the causes that produce them? Justice Hughes once said it was foolhardy to keep on increasing appropriations to care for the victims of bad housing while we overlooked the conditions that produced them.

What we need in Philadelphia is a constructive programme that will eliminate present evils and prevent the development of new areas along the lines of past mistakes. Patchwork programmes and temporizing policies should be relegated to the incinerating plant.

It might be difficult just now to demonstrate to Philadelphians that there is any connection between bad housing conditions and sickness and a high death rate. It is commonly known to sanitarians that the sanitation of Philadelphia, in certain wards, is especially bad. Until the past year the death rate for the city was very high. In 1912 it dropped to 15.22 per 1,000, and in the minds of some people this was proof positive of the falsity of the statements about the insanitation prevalent. As a rule, the death rate for a single year is a mighty poor barometer of the actual health conditions, so many factors enter in to make the mercury go up or down. We did have a low death rate that year, but so did other cities in the country. Out of 36 other cities of over 100,000 population 23 also reduced their rate, some as high a reduction as 2.1 and 2.4 and 2.63 per 1,000. Exceptional conditions favored the public and reduced for the time the toll levied on them by the insanitary areas. Even then, as a matter of fact, out of 45 registration cities having populations of over 100,000, reports from which have come to our office, 23 had lower death rates than Philadelphia and 21 higher rates. Among the cities having a lower death rate were Chicago and New York, although both have a larger population. Although, therefore, we dropped lower that year that ever before in our rate, yet we need not become too self-satisfied. We are still 24th from the top on the list of large cities, and approximately during the year 8,000 deaths occurred from diseases that are scientifically known as preventable. If these preventable deaths were from any cataclysmic cause we would be horrified. "If such a calamity occurred in a single day and it was preventable," to quote a well-known insurance society, "and was not prevented, the dereliction would be regarded as a crime." "Is it any less a crime," they add, "that it takes 365 days instead of one day to destroy these lives?" Not all, by any means, of these deaths can be laid at the door of bad housing, but without doubt a large percentage can be so charged; for from centers of infection circles of infection radiate, and who knows to what boundaries the outermost circles go? Mediums of transmission are many, and while the ulcers last none are safe.

I have perhaps dwelt upon the health aspect of bad housing a little too long. It does not follow that all such deaths are due to environmental influences; but in part they have a causal relationship.

There is another cost we are paying, and this can be spoken of in terms of morals. You are familiar with the statement made by juvenile workers "that 90 per cent of the children that enter the children's courts

come from bad environmental influences." We made a study of the effect of the alley house, the lack of play space and the insanitation of one congested block, and we found that all the alleys sent their representatives to the children's court in 1910. In the block there were 1,106 people, and 629 arrests occurred in three years. This means one arrest each year for every four people, leaving the babies out. The data collected from Liverpool showed that the number of arrests dropped 50 per cent, although the new housing scheme took in 70 per cent of the people.

It stands to reason that the very condition of the overcrowding does not allow the play instinct of the child to get an opportunity to express itself in ways that are safe, while the irritation so often shared by all adults when expressed in the crowded court lead to frequent encounters that result in transgressions of the law.

The side that is the most pernicious, because perhaps it cannot be measured, is the breakdown of the morals of the young people attendant upon their living so many in a room. The young girl cannot preserve her maiden reserve when she must occupy the room with her parents and the ever-present boarders. When whole families live, sleep and cook, entertain their friends, tend their sick and bury their dead from the one-room apartment there is little chance for morality to be conserved or developed. Is it any wonder that under the stress of living, with the temptations that assault the poor, the moral standards fall and practices are indulged in that are classified by society as immoral?

But the economic loss is the greatest. The individual pays, and so does society. The individual pays in the loss of ambition and vitality, the loss of wages, the doctors' bills and the druggists' bills and many similar denials that lead to poverty in its worst forms. Society loses in the bills it has to pay for the care and prevention of the spread of contagion and the victims of such. Do you realize that in five years from 1907 to 1911 there were 109,066 cases of contagious diseases from 6 of the 27 diseases classified by the Board of Health as contagious? Of this number, 31,375 deaths occurred. I have not had time to determine the number of cases of such diseases cared for by the city and private hospitals as charity cases, but I know that the average cost for a number of years to the city for hospital care is $2.00 per day per patient. There is added to this the annual cost paid for the work of the Health Bureau. For the child sent to the reformatories, etc., there is a weekly cost of $3.00 per child. When you realize that we are 20 centuries almost away from the date Christianity is supposed to have begun, and the far longer period civilization has been at work upon the race, it is a sad commentary upon the work done that we need larger hospitals and asylums and poor-houses, larger police force, larger and more courts, judges and all the kindred staff called into being by the manner of living of men. Not all, by any means, is traceable to bad housing, but this plays a large part, in that environmental influences are at play to mold for good or ill those who come within its sphere. If the figures of English statisticians are correct there is an average of 20 cases of sickness for each death and 20 days' loss of work for each sickness. On this basis the economic loss to Philadelphia for the 8,000 to 9,000 lives needlessly sacrificed amounts to from $4,000,000 to $6,000,000, a loss that is increased when it is remembered that with it goes the drain upon public and private charities for the care and upkeep of the families thrown by such sickness over the cliffs into the chasm of poverty.

I do not intend to appear a calamity howler in this matter, but the conditions are here and in every city. They are the consequences of a lack of a community programme. Such a community programme is readily drafted. It needs the attention of men of your profession. I can best let my last remark to you be a repetition of a question asked of me by a poor man in a southern ward: "What are you going to do about it?"

Powdered Coal Under Boilers*

By William A. Evans

EARLY experiments with powdered coal amounted to a general education and the discovery of the elementary principles upon which it operates. Failures were then primarily due to defects in pulverizing apparatus and that for feeding the powdered coal to the furnace. The principles of operation have become well established and the apparatus well standardized. The elements of good powdered-fuel combustion consist of finely ground coal, 90 per cent through standard 100-mesh screen, thorough mixture of coal and air before entering the furnace, and good control of both coal and air. With these elements worked out properly, powdered fuel has shown marked economies on many furnaces and the results obtained are worth striving for in the case of boilers.

To the writer's knowledge, but two types of boiler have shown any success. Several attractive results have been obtained on horizontal return-tubular boilers, a battery of six having been operated for eight years at one plant and requiring but one man to run the entire plant. Of the water-tube type of boiler, none of the standard makes has shown any permanent results, although there is a boiler designed specially for powdered coal that, according to reports, is giving satisfactory commercial results. The return-tubular and this special boiler have combustion space for the amount of fuel burned much in excess of what is provided in most water-tube boilers. This large space seems to be the one essential.

The points of furnace design which are likely to bring about the successful use of this fuel under boilers are: Large combustion space, firebrick lined with no exposed boiler surface; means for disposing of ash; design of furnace, water cooled, that will insure a reasonable length of life to the firebrick setting, and provision for firing from a cold boiler without the use of auxiliary power to run the pulverizer and air supply.

In most experiments with boilers using powdered coal these four essential features of furnace design have been disregarded. Powdered coal requires a high temperature for ignition and for maintained combustion; at all parts of the furnace it should be at least 1,800 deg. Fahr. As these temperatures cannot be maintained and the combustion completed in contact with boiler-tube surfaces, a large space not in contact with the tubes has to be provided.

For the complete burning of powdered coal a space of one cubic foot for each boiler horse-power developed should be provided, because of the difficulty with which high-volatile coal burns on grates. Volatile gases escape from the grates, and unless there is a hot arch above and plenty of space, the gases escape to the tubes, where the flame is stifled with resultant smoke. The volatile matter is the most difficult part of the coal to burn with grate fires, but it becomes the more easily burned in the case of powdered-fuel combustion. This is because combustion of the coke occurs while suspended and traveling. In a hot furnace the volatile matter burns promptly while the coke burns as it travels forward, and the time required for combustion depends upon the size of the particle. The length of travel of the flame before it reaches the water tubes of the boiler should be such as to insure complete combustion, both volatile and fixed carbon, before it reaches the boiler surface. Large space then (one cubic foot for each boiler horse-power maximum) is one of the first requirements of a boiler furnace using this coal. This space can be made doubly effective by causing the flame to make a double travel; that is, forward and backward, or up and down within the space, depending upon the design and local conditions.

Probably the most troublesome feature of powdered-fuel combustion under boilers has been the handling of the ash. When combustion is perfect, with the boiler operating at capacities required in present-day practice, heat is developed much above the fusing point of the ash or the brick, and both form a heavy slag hard to remove. In metallurgical furnaces this feature is taken care of in the slagging of other impurities, but fused ash in the boiler furnace is not so easily cared for. As it moves very sluggishly at a temperature of 2,500 degrees and will become solid at 1,200 degrees, it is, therefore, difficult to remove, for as soon as any door is open for scraping out, it clings to the brickwork with a tenacity difficult to realize, except after experience. It may be possible that a flux can be used to make this ash more fluid at low temperatures with small boiler capacities and exceptionally good coal, but the writer questions its practicability on large boiler capacities and on all grades of coal. He further believes that the ultimate solution of the use of powdered coal in boiler furnaces will include a positive means for continuously removing the ash.

In metallurgical work it is customary to frequently rebuild the furnaces, say, every eight to twelve weeks. In using powdered coal in these furnaces the life of the brickwork is somewhat reduced, usually requiring rebuilding every six weeks. Frequent rebuilding of boiler furnaces is highly objectionable, and the high temperatures of powdered coal will certainly destroy the best setting, unless some new provision is made. It has been suggested that temperatures in the furnace be reduced by introducing excess air, but this is not practicable, as it would reduce the efficiency of the boiler. On the Bettington boiler as specially designed for powdered coal, the brickwork is maintained by the use of water-cooling tubes, the bricks being specially made to fit around the tubes. It would seem essential that furnaces be built with all the walls cooled by water tubes, the water in which is in circulation with that in the boiler.

The matter of starting up from a cold boiler without auxiliary apparatus is, of course, possible of several solutions, and does not affect the primary success of the boiler in the burning of powdered coal. Fuel oil or gas might be used for getting up steam, or a grate could be incorporated in the design to permit of hand firing.

The features suggested necessarily require an elaborate change in boiler setting. The writer knows of but one case where any such elaborate change was made and that did show very intense heat with good combustion, but no provision was made for maintaining the brickwork, so it failed. The reason for the present-day lack of success with powdered coal under boilers is that each attempt has been made without any definite knowledge of what had previously been done or of the failures of others. Many attempts have been made by innocent purchasers of apparatus sold by ambitious promoters. In these cases the promoter knew nothing but the fact that powdered coal was giving success in some industries and that it ought to work to considerable advantage under boilers. Even if he knew that the redesigning of the setting was necessary or desirable, he would promote the sale by suggesting some slight change in the existing setting, hoping that enough would be developed to encourage the purchaser to continue to the ultimate success of the installation and education of himself.

It is fair to expect that, if a combination of the best elements of coal grinding, coal and air control, large combustion space, means for ash removal and brick maintenance be made in applying powdered coal to a boiler, there will be some success, and the economies already proved will be on the road to a commercial reality.

There is a good field for the use of powdered coal and we may expect to see it further developed.

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Table of Contents

PAGE
Recent Discoveries in Physical Science.—I.—By Sir J. J. Thomson.—1 illustration 258
Table of Feet Reduced to Decimals of a Mile.—By James G. Wishart 259
Hat-pin Menace, The 259
Machine Tools and the Motor Car Industry.—5 illustrations 260
Evolution of the Breech-loader.—By Alex. Del Mar.—7 illustrations 261
Decline of the American Navy, The.—4 illustrations.—By Sidney Graves Koon.—4 illustrations 262
Desirable Developments in Ship Dimensions 263
Joints in Materials for Aircraft.—By Pegasus 263
Annual Aero Show in London, The.—I.—36 illustrations 264
Electric Emissivity of Matter, The 266
Snapshot Photography.—By C. H. Claudy.—6 illustrations 268
Blood Pigment and Chlorophyll.—By Dr. O. Damm.—3 illustrations 269
Loaf of Bread, The 269
Colossal Waste Due to Bad Municipal Engineering.—By Bernard J. Newman 270
Powdered Coal Under Boilers.—By William A. Evans . . 273